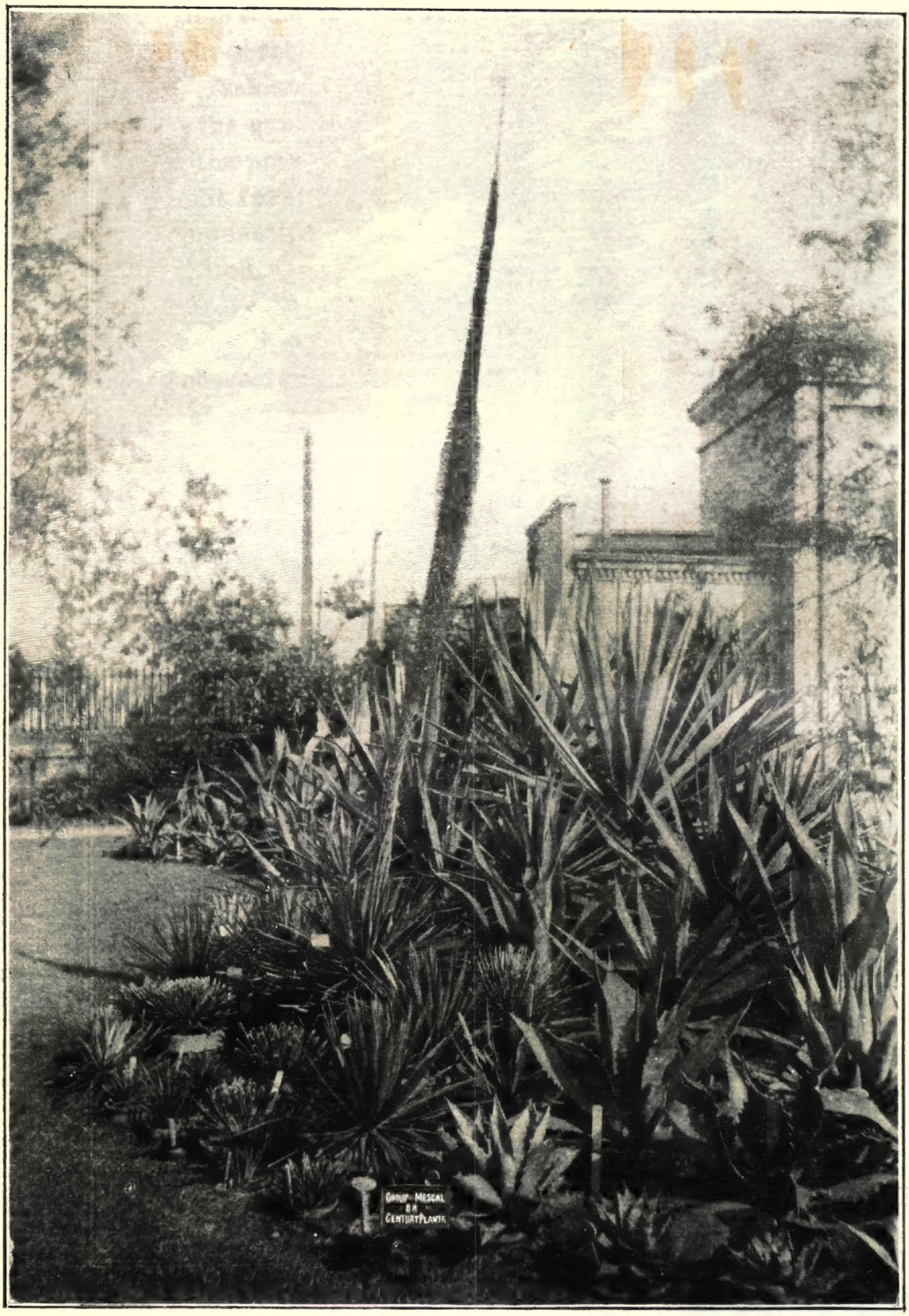

AGAVE FILIFERA FILAMENTOSA.

MISSOURI

BOTANICAL GARDEN.

ELEVENTH ANNUAL REPORT.

ST. LOUIS, MO.:
PUBLISHED BY THE BOARD OF TRUSTEES.
1900.

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---

* *Ex-officio.*

1 Elected President of the Board of Public Schools of St. Louis, October 10, 1899, to succeed Edward C. Eliot, who had held that office for one year.

PREFACE.

By authority of the Board of Trustees, the eleventh annual report of the Missouri Botanical Garden is presented to the public.

The tenth report was issued June 5, 1899. Separates of the following papers contained in the present volume were issued on the dates noted: Von Schrenk, A disease of Taxodium, etc., June 3, 1899; Rose, Agave expatriata, etc., June 3, 1899; Norton, A revision of the American species of Euphorbia of the section Tithymalus, etc., July 10, 1899; Smith, Revision of the species of Lophotocarpus, etc., September 27, 1899.

These reports are sent to scientific institutions and journals, in exchange for publications and specimens desirable for the library, herbarium, or collection of living plants of the Garden. So far as possible, reprints of the botanical articles they contain are sent to botanists occupied with a study of the subjects treated. Any of the Garden publications not out of print may be purchased, at approximately the cost of publication, from the Cambridge Botanical Supply Co., Cambridge, Mass.; A. I. Eriksson, Tufts College, Mass.; R. Friedländer & Sohn, Berlin, Germany; W. Wesley & Son, London, England, or the undersigned.

WM. TRELEASE.

St. Louis, Mo., Jan. 10, 1900.

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IN THE ARBORETUM.

REPORTS FOR THE YEAR 1899.

REPORT OF THE OFFICERS OF THE BOARD.

SUBMITTED TO THE TRUSTEES JANUARY 10, 1900.

To the Board of Trustees of the Missouri Botanical Garden:

We herewith present financial results of the year ending Dec. 31, 1899. We are glad to report a considerable gain in rentals, the excess being $2,881.13 over the previous year, the increase being largely the result of vacancies filled and continued occupancy in the smaller buildings in the business district.

Much of the revenue property of the Trust is located in the section near the river between Washington Avenue and Market Street, which at one time was the most valuable in the city, but the revenue from this property has been steadily declining for many years until the present rental is about one fourth of what it brought when purchased by Mr. Shaw, but even at that figure yields a fair percentage upon present values, and we think rentals in that locality have reached their lowest point. Recently we have leased several buildings for terms longer than one year at the old rental, which would have been impossible several years ago.

The property that is owned by the Trust located west of Fourth Street in the business district is enhancing in value, and after the expiration of the present leases an increased rental is anticipated.

We are unfortunately the possessors of many old and dilapidated buildings which demand considerable expenditure

to keep them in rentable condition, but they are nearly all occupied by desirable tenants.

We are at last able to report that the Supreme Court of the State of Missouri has favorably granted the application of the Trustees made in October, 1897, for power to dispose of certain properties, and the decree was entered June 30th authorizing the Trustees to sell two tracts of land, known as Nos. 3 and 4, lying between Grand Avenue and Old Manchester Road and McRee and Flora Avenues embracing about 166 acres of valuable residence property which should, when improved, sell for at least $1,500,000.00.

The Trustees, fortunately, by joining with the property owners on the south side of Flora Avenue, were enabled to improve the property fronting on that street in a very handsome manner and are now able to offer for sale that tract (No. 3) of 4,400 front feet. It is one of the most desirable residence sites in the city. This property has been advertised for sale and a number of inquiries have been received and it is hoped sales will be made in the early spring. As that tract is being disposed of it will undoubtedly be for the best interests of the Trust to use the proceeds for the improvement of the other and larger tract (No. 4) which will contain, when platted, about 35,000 front feet of desirable residence property conveniently located. The proceeds of this tract (No. 4) will be invested in down-town business property or approved securities as directed by the decree of the Court, the revenue from which can be used for the support of the Garden.

As will be seen by the following statement the Garden has been well provided for, but no new buildings have been erected. Bids are now being taken for grading the proposed addition to the Garden of about 20 acres which it is anticipated will be in condition for planting in the spring. Additions have been made to the already very large library and herbarium, and the following sums have been credited to the Stock Account, which aggregates $1,576,207.20: —

Library	$3,017 62
Herbarium	4,938 50
	$7,956 12

Mr. Shaw's bequests for banquets, sermon, flower show, and the Shaw School of Botany have been carried out as provided for in the will, and after supporting the Garden and expending such sums as were needed for repairs, insurance, taxes, etc., all out of the year's income, we are enabled to carry forward a surplus for the year of $15,146.09.

RECEIPTS.

Rents	$99,393 41	
Interest and dividends	2,126 65	
Garden pasturage and sales	438 04	
Garden handbook sales	58 00	
Publication sales	13 98	
Insurance of buildings (loss)	52 00	
Opening of streets	3,191 00	$105,273 08
Cash on hand Jan. 1, 1899		755 07
Total		$106,028 15

EXPENDITURES.

Garden Account,		
Labor pay-roll	$13,183 88	
Students' pay-roll	1,583 30	
Office assistance	713 40	
Fuel	1,034 73	
Water	422 00	
Repairs and supplies	1,581 53	
Stable and implements	473 99	
Plants and seeds	816 37	$19,809 20
Herbarium Account,		
Office assistance and janitor	441 88	
Extra mounting and inserting	142 80	
Fuel	80 18	
Current expenditure and specimens	1,913 21	2,578 07
Library Account,		
Office assistance	1,167 20	
Fuel	80 18	
Current expenditure and books	1,906 50	3,153 88
Carried forward		$25,541 15

Brought forward		$25,541 15
Office Account,		
Salaries	$4,570 38	
Fuel	80 29	
Current expenditure	296 25	4,946 92
Research Account,		
Salaries	788 16	
Drawing of plates	180 00	
Current expenditure	87 68	1,055 84
Scholarship Account,		
Instruction	594 50	
Care of lodge	240 00	
Fuel	50 43	
Current expenditure	183 56	1,068 49
Total current Garden expenses		$32,612 40
Garden Improvement Account		535 50
Total on Garden		$33,147 90
Publication Account,		
Annual volume	2,257 66	2,257 66
Property Expenses,		
State, school and city tax	24,460 42	
Streets, sidewalks and sewers	4,445 61	
Insurance	4,922 64	
Repairs	5,835 34	
New improvements	500 00	40,164 01
Office Expenses,		
Salaries	3,600 00	
Rent of office	780 00	
Printing, postage, telephone and advertising.	613 11	4,993 11
Bequests,		
Flower Show	480 00	
Flower Sermon	200 00	
Trustees' Banquet	900 60	
Gardeners' Banquet	362 35	
Washington University	800 76	2,743 71
Sundries,		
Legal expense	7,925 21	
Repairs to building, loss by fire	50 00	
Books	100 00	8,075 21
		$91,381 60
Cash on hand Dec. 31, 1899		14,646 55
		$106,028 15

The books of the Board have been closed after showing the operation for the year ending December 31, 1899, and the receipts have been disposed of as follows: —

Rent account	$99,393 41	
Interest and dividends	2,126 65	
Garden handbook	58 00	
Losses by fire	2 00	$101,580 06

CONTRA.

Garden expenses	$32,274 36	
Garden improvements	535 50	
Office expenses	4,993 11	
Repairs	5,835 34	
Insurance	4,922 64	
New improvements	500 00	
Washington University	800 76	
Annual Flower Sermon	200 00	
Annual Flower Show	480 00	
Annual Trustees' Banquet	900 60	
Annual Gardeners' Banquet	362 35	
Publications	2,243 68	
Legal expenses	7,925 21	
	$61,973 55	
Taxes	24,460 42	$86,433 97
Surplus for the year		15,146 09
		$101,580 06
Surplus to Dec. 31, 1898		$90,324 11
Surplus for 1899		15,146 09
		$105,470 20

Our surplus on December 31, 1899, accounted for as follows: —

Improvement of Flora and Shaw Avenues	$40,823 65
Bank Certificate of Deposit	50,000 00
Cash	14,646 55
	$105,470 20

Respectfully submitted,

R. J. Lackland, President.

Attest:

A. D. Cunningham, Secretary.

ELEVENTH ANNUAL REPORT OF THE DIRECTOR.

SUBMITTED TO THE TRUSTEES JANUARY 10, 1900.

To the Board of Trustees of the Missouri Botanical Garden:

The following report on the Missouri Botanical Garden and the Henry Shaw School of Botany is respectfully submitted in compliance with your rules.

THE BOTANICAL GARDEN.

During the past season, the decorative features of the Garden have been maintained on about the same lines as in previous years. In the spring a very small synoptical collection representative of the principal natural orders of flowering plants was installed in the central part of the Garden, where it is proposed to continue it as a convenient means of enabling teachers in the public schools to demonstrate to their pupils the characters of the larger plant groups. The collection embraces 318 species, pertaining to as many genera, and representing 100 orders. A group of trees and shrubs, comprising 140 species and 13 varieties, was set in the autumn at the east of the Director's residence in conformity with the general plans suggested by the landscape architects of the Board for the future treatment of the grounds now comprised in the Garden, and a small mass of evergreens thought to be capable of enduring the increasing smoke of our atmosphere was set out near the southern apex of the present arboretum.

Considerable additions have been made to the plants cultivated in the several departments of the institution, the

GROUP OF ALOCASIA ODORA.

total number of species and varieties in cultivation now being 9,127, of which 5,875 are annuals or hardy perennials, and 3,252 receive the protection of plant houses during the winter. This shows a net gain of 1,118 as contrasted with the end of 1898.* The plants added during the past year represent 227 entries, of which 45, including 2,793 plants or packets of seeds, were bought, 41, including 17,532 plants or packets of seeds, and valued at $1,101.78 were collected or propagated by employees of the establishment, and 141, comprising 5,049 plants or packets of seeds and valued at $635.95, were presented, largely in exchange for similar material or for the publications of the Garden. The expenditure for plants and seeds, as shown by the Secretary's statement, amounts to $816.37. By way of exchange, 195 packets of seeds and 350 plants, appraised at $77.65, were sent out; and 1,840 plants were presented to schools and charities in continuation of the policy for some years past.†

The decree of the Circuit Court, City of St. Louis, rendered in 1896 and authorizing the sale of certain unimproved real estate held by the Board as a part of the endowment of the institution, from which an appeal was taken by the Attorney General to the Supreme Court of the State,‡ has been affirmed, as to its essentials, by that Court, in a decree handed down on the thirtieth of June, 1899, so that the Trustees of the Garden are able to look forward to the gradual conversion of a large amount of unproductive, heavily-taxed property, into an income-producing form, while relieved from the past need of withholding from the current revenue a large sum annually, for the protection of this property whenever the improvement of the streets through it should be ordered by the City.

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* Report. **10**: 15. In 1899, 258 species or varieties were lost, and 1,376 added.

† Report. **10**: 15.

‡ Report. **8**: 35.

As a first step in the marked advance which may be looked for in the Garden, the Board have authorized the grading of about twenty acres of ground lying between the present Garden and Tower Grove Park, according to the plans prepared some years since by Olmsted, Olmsted and Eliot, the intention being to plant this area as a permanent addition to the grounds in such a way as to add greatly to their attractiveness, while representing in a compact form the leading features of the North American flora.* There is reason to hope that, on the completion of this extension, some eighty acres additional of land lying to the west of the present Garden may be improved, in accordance with plans furnished by the same landscape architects, in such manner as to represent the most modern views of the relationship of as many of the natural orders of plants as can be grown successfully in the climate of St. Louis,† while the present insufficient plant-houses will doubtless be proportionately increased and improved.

In midsummer of 1898 a definite count of visitors entering the Garden by the main gate was instituted, and it was estimated that some 89,102 persons visited the grounds during 1898.‡ This count has been continued through the past season, with the result of showing 54,429 visitors for week days, 7,755 for the open Sunday in June, and 8,837 for the open Sunday in September, or a total of 71,021 for 1899. A comparison of the record for week days of the last five months of the two years, shows a decrease in 1899 of 3,339, although, when the September Sunday is counted in for each year, 33 more persons are found to have visited the Garden in the last five months of 1899 than in the corresponding months of 1898.

The herbarium, as in previous years, has received the most important current collections, particularly those representative of the North American flora. A collection of

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* On details of this subject see Report. 8 : 38.

† Report. 8 : 39.

‡ Report. 10 : 16.

some 5,700 specimens (of which some 3,200 are duplicates, to be used in future exchange) largely of Vermont plants, collected by Dr. Ferdinand Blanchard, was received in the early part of the year from Mrs. Alice F. Stevens of Washington, in exchange for an equivalent amount of duplicate material from the Garden herbarium which she directed sent to Dartmouth College. In December about 8,300 specimens were purchased from the estate of the late Dr. A. W. Chapman, of Apalachicola, Fla., of which some 3,200 specimens had constituted his personal reference collection for many years.* Neither of these collections has yet been inserted in the herbarium of the Garden. The material actually incorporated in the herbarium during the year amounts to 32,890 sheets of specimens, of which 15,863 were bought, 4,930 pertain to the Redfield herbarium, † 1,451 were collected by Garden employees, and 10,646, appraised at $532.30, were presented, chiefly in exchange for Garden publications and specimens. By way of exchange, 5,272 herbarium specimens, valued at $263.60, were distributed to correspondents.‡

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* Concerning these specimens, Dr. Chapman wrote in November, 1898: "When I commenced making a herbarium I cut any stiff paper that came to hand into sheets 15 by 10 inches, inclosing them in binder's boards, book-form, on which I fastened the specimens, on some a single one, or two or more species. The collection thus made has been my working herbarium ever since, and contains some 2,500 to 3,000 species of plants, some of them fastened to buff sheets but all later additions loose. There are about fifty volumes of them, ranging in thickness from one to six inches. When I was writing the first edition of my Flora, these sheets were spread out before me and the plants now remaining on them are to be considered typical, — but since then many have been detached, some to make up the herbarium that I sold to Vanderbilt, and some that I sent to you and to Columbia College. Since then the additions have been placed loosely in the covers. Scattered through the volumes are my notes, descriptions, etchings, and guesses."

† Report. **9**: 14. **10**: 17, 18.

‡ It should be noted that this includes 4,098 specimens sent in settlement for the large Blanchard collection, which does not appear in this year's incorporations in the herbarium, being still held for mounting.

The present composition of the herbarium is as follows: —

The Engelmann Herbarium (all groups), about..... 97,800 specimens.

The General Herbarium: —

Higher plants.

The J. J. Bernhardi Herbarium.....	**61,121**		
The J. H. Redfield Herbarium.....	**16,436**		
Other specimens.....	**142,318**		
		219,875	**"**
Thallophytes.			
The J. J. Bernhardi Herbarium*....	**126**		
Other specimens.....	**22,549**		
		22,675	**"**
Making a total of about.....		**340,350**	**"**
Valued at.....			**$51,052 50†**

The following, practically a part of the herbarium, is essentially the same as for some years past:‡ —

Wood specimens of various sizes.....	**1,027,**	**valued**	**at**	**$100 00**
Wood veneers, by Spurr, Hough, Nördlinger, and Michel	**2,279,**	**"**	**"**	**160 00**
Microscope slides, by Hough, Penhallow, Munroe, and others.....	**1,051,**	**"**	**"**	**250 00**
Together.....	**4,357,**	**"**	**"**	**$510 00**

The additions to the library for 1899 include 131 books and 28 pamphlets purchased, and 511 books and 144 pamphlets, valued at $920.50, presented or sent in exchange for Garden publications.

The manuscript index has been increased by the incorporation of 9,062 new cards, of which 2,762 were bought, and 6,300 written by employees of the Garden.

*** So far as yet incorporated.**

† The valuation of such collections is purely arbitrary, since they could not be exactly replaced for any amount of money, in case of loss; but they are appraised at $15.00 per hundred mounted sheets. — Report. 10: 18.

‡ Report. **8: 20. 9: 15. 10: 18.**

As now constituted the library contains: —

Pamphlets	19,175			
Books (general)	13,758			
	32,933	valued at		$49,030 67
Books (Sturtevant Prelinnean Library)*	463	"	"	2,315 00
MS. volumes (Shaw, Engelmann and Roetter)	66	"	"	800 00
Total	33,462	"	"	$52,145 67
Index cards.				
Various	201,447			
Sturtevant Index	52,300			
Total	253,747	"	"	2,537 47
Total valuation				$54,683 14

A general catalogue of the library, to which reference has been made in previous reports,† has been kept closely abreast of the additions to the library, but as yet no definite steps have been taken looking to its publication, although it is hoped that this may be effected in the near future.

The office staff has continued unchanged since my last report,‡ except that near the end of December Mr. Thompson resigned his position as library assistant, the position vacated being filled by the appointment of Mr. Jesse B. Norton.

The sales of the small handbook, at the gate, amount to 232 copies for 1899, and 7 copies were given away.

The exchange relations of the Garden have been increased by the addition of 28 institutions and 47 publications. There are now received at the Garden library 978 serial

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* The original number and arbitrary valuation of the collection presented by Dr. Sturtevant (Rept. 8:21). On the Prelinnean shelves are now found a much larger number of volumes than is indicated here, the addition and valuation of these, however, from year to year being included in the general accession lists and the valuation of the library as a whole.

† Report. 9:16. 10:21. ‡ Report. 10:22.

publications, of which 91 are bought and 887, issued by 688 institutions, are presented.*

As in previous years, a number of visiting botanists and resident students have made serious use of the facilities of the Garden, and transcripts from the library have been made extensively and material for investigation has been loaned freely to responsible persons not able to come to St. Louis.

By permission of the Board, the Director of the Garden spent the months of June and July in a study of the botany of the Alaskan coast region and the islands of Bering Sea, as a member of the Harriman Alaska Expedition, the scientific results of which will no doubt be published in suitable form after the large amount of material collected has been subjected to critical study.

Approximately the same amount of time as in preceding years has been given to research work by the office staff. The results of some of this work appear in the eleventh Report, and other papers have been published elsewhere or will be published from the Garden later.

The instruction of Garden pupils has been carried on during the year on the lines stated in my last report.† Two pupils, Walter Nehrling and Walter Retzer, having complied with the requirements, were awarded certificates in March last. The scholarships freed by their graduation were awarded respectively on the result of competitive examination and by nomination of the St. Louis Florists' Club, to Bruno Nehrling, of Milwaukee, Wisconsin, and Rudolph J. Mohr, who had been a paying pupil for the year preceding. In August, Ernest P. Field, who held a scholarship on the nomination of the Missouri Horticultural Society, withdrew from the Garden, and the Secretary of the Horticultural Society designated as his successor Robert Meyer, of St. Louis, who had been in the employ of the Garden for some time, and to whom a scholarship was awarded in October.

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* Report. **3**: 16. **10**: 25, 91.

† Report. **10**: 26.

Four annual events provided for in Mr. Shaw's will have taken place, as follows: The preaching of a sermon on the wisdom and goodness of God, as shown in the growth of flowers, fruits and other products of the vegetable kingdom; the tenth banquet to the Trustees of the Garden and their invited guests; the tenth banquet to the gardeners of the institution, and invited florists, nurserymen and market gardeners; and the award of premiums or prizes at a flower show held in St. Louis.

The flower sermon was preached in Christ Church Cathedral, St. Louis, on the morning of May 14, by Rt. Rev. M. N. Gilbert, of St. Paul, Minnesota.

The Trustees' banquet was given at the St. Nicholas Hotel, on the evening of May 13, and was presided over by President E. C. Eliot, of the Board of Education of St. Louis. Sixty-six gentlemen, comprising members of the Board of Trustees and literary and scientific men and friends and patrons of the natural sciences, were present. Speeches appropriate to the occasion were made by President Charles W. Dabney, of the University of Tennessee, President J. H. Finley, of Knox College, Rt. Rev. M. N. Gilbert, Bishop of Minnesota, Rev. Leon Harrison, of St. Louis, and Professor J. M. Coulter, of the University of Chicago.

The banquet to gardeners, nurserymen and florists was given at the Mercantile Club on the evening of November 18. One hundred and thirteen persons were present. The Director of the Garden presided, as directed by the will of Henry Shaw. Appropriate toasts were responded to by Professor C. M. Woodward, President of the Public School Board of St. Louis and a member of the Board of Trustees of the Garden; Mr. J. F. Ammann, of Edwardsville, Illinois, President of the St. Louis Florists' Club; and Mr. James Hartshorne, of Chicago, President of the Chicago Florists' Club. The principal effort of the evening was devoted to a consideration of the practicability of improving public

school grounds, by suitable planting, and addresses on this subject were delivered by Professor J. C. Whitten, of the University of Missouri, Mr. James Newton Baskett, of Mexico, Missouri, Professor W. J. Stevens, of Carthage, Missouri, and Honorable Norman J. Colman, formerly United States Secretary of Agriculture.*

As in previous seasons, the award of premiums for flowers and plants was intrusted to the St. Louis Florists' Club, on the occasion of their Chrysanthemum Exhibition, held in the Coliseum of the Exposition Building, Nov. 14 to 19, inclusive. In the main, awards were made for the general class of exhibits heretofore approved. In the early part of the season notices were inserted in several of the trade journals, calling attention to the Shaw medal for a plant of decided merit for cultivation not previously an article of North American commerce, and introduced to such commerce by the exhibitor during the year in which said award is made.†

As a result, this year three plants were entered in competition for the gold medal, two of which were really choice plants such as the establishment of the medal was intended to enable the residents of St. Louis to see. The medal was awarded to Henry Clinkaberry, gardener to Mr. C. S. Roebling, of Trenton, N. J., for a hybrid *Cypripedium* named James K. Polk and said to be a cross between *C. nitens magnificum* and *C. Chamberlainianum*. With the permission of Mr. Roebling, Mr. Clinkaberry has presented to the Garden the specimen on which the award was made.

THE SCHOOL OF BOTANY.

The undergraduate work of the Henry Shaw School of Botany for the past year has been conducted on the lines announced in my earlier reports.‡

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* The proceedings are reported at length in the issues of Colman's Rural World of Nov. 30, Dec. 7, and Dec. 14, 1899.

† Report. **5**: 18, 19. **9**: 19. **10**: 32. ‡ Report. **10**: 33.

CYPRIPEDIUM JAMES K. POLK.

At the beginning of the College year 1899–1900, Mr. Herbert F. Roberts was appointed Instructor in Phanerogamic Botany, in place of Mr. W. H. Rush, who resigned his position in the spring, after four years of efficient service. Several special students and candidates for advanced degrees have been in residence and have made use of the facilities of the laboratory, and at the commencement exercises of June, 1899, the degree of Doctor of Philosophy was conferred by the University on two of these persons, — Professor Louis H. Pammel of the Iowa Agricultural College,* and Mr. Hermann von Schrenk of Washington University.†

Very respectfully,

WILLIAM TRELEASE,
Director.

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* Dr. Pammel's thesis, entitled Anatomical characters of the seeds of Leguminosae, chiefly genera of Gray's Manual, was published as vol. 9, no. 6, of the Transactions of The Academy of Science of St. Louis (pp. 91–273. *pl. 7–35*).

† Dr. von Schrenk's thesis, entitled A disease of *Taxodium distichum* known as peckiness, also a similar disease of *Libocedrus decurrens* known as pin-rot, appears in the present volume (*infra*, pp. 23–77. *pl. 1–6*).

SCIENTIFIC PAPERS.

A DISEASE OF TAXODIUM DISTICHUM KNOWN AS PECKINESS, ALSO A SIMILAR DISEASE OF LIBOCEDRUS DECURRENS KNOWN AS PIN-ROT.*

BY HERMANN VON SCHRENK.

INTRODUCTION.

The diseases of forest trees had attracted attention for many years before any attempt was made to arrive at an understanding of their true nature. With the investigations of Th. Hartig,† Schacht,‡ and Willkomm,§ a beginning was made, but not until the epoch-making researches of R. Hartig,‖ were some of the complex relations between diseased trees and the exciting causes made clear. In England, Marshall-Ward has paid some attention to the diseases of trees, but in this country few have given this subject much study.

A tree may be diseased because of the natural decadence of its vital forces incident to old age, it may be influenced by abnormal physiological conditions, or its functions may be impaired by the activities of a disturbing organism.

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* A thesis presented to the Faculty of Washington University for the degree of Ph. D., April, 1899.

† Hartig, Th. Abhandlung über die Verwandlung der polycotyledonischen Pflanzenzelle in Pilz u Schwammgebilde, u. die daraus hevorgehende Fäulniss des Holzes. 1833.

‡ Schacht, Hermann. Der Baum, Studien über Bau u. Leben der höheren Gewächse. Berlin. 1860.

§ Willkomm, M. Die mikroscopischen Feinde des Waldes. Dresden. 1866.

‖ Hartig, R. Wichtige Krankheiten der Waldbäume. Berlin. 1874.— Die Zersetzungserscheinungen des Holzes, etc. Berlin. 1878.

Separates issued June 3, 1899.

Examples of the first class of disease need not be given; the root rot of pines * is an example of the second class, and the numerous fungi (and insects) attacking different parts of a tree come under the third class. It is particularly the latter class which Hartig has studied and with some of which the present paper is to deal.

The fungi attacking trees may be divided for convenience into such as are strictly parasitic, like the Peridermiums, Exoasci, Gymnosporangiums, etc., and such as are not. Among the latter class one finds various grades, going from the strictly parasitic to the strictly saprophytic forms, including the facultative saprophytes (of De Bary) or hemiparasites, the true saprophytes, and the facultative parasites (De Bary), or hemisaprophytes. Of the fungi which attack the trunks of trees, i. e., the wood already formed, few are strictly parasitic or hemiparasitic; the majority are hemisaprophytes, for although normally growing on dead matter they may occasionally become truly parasitic. Tubeuf † mentions a number of such fungi, among them several common in this country, such as *Trametes Pini*, *Polyporus fomentarius*, *Polyporus sulphureus*, and others. *Trametes Pini* may serve as a good example. When growing on species of pine, such as *Pinus palustris*, *Pinus Strobus*, *Pinus echinata*, it flourishes in the heartwood of these trees as a strict saprophyte, i. e., on the dead wood. The resinous contents of the living wood prevent its becoming parasitic. On the other hand, when growing on *Abies balsamea* or *Picea nigra* it becomes a parasite, growing likewise in the living wood and ultimately killing the tree. The diseases to be discussed in the following are due to hemisaprophytes, as they affect the heartwood of the trees and never enter the living parts of the trunks.

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* Hartig, R. Zersetzungserscheinungen, etc. 75.

† Tubeuf, C. Freiherr von. Diseases of plants 5. (English edit. by W. G. Smith. 1897.)

Some years ago, while collecting in the cypress swamps of Arkansas, a peculiar defect of the bald cypress, *Taxodium distichum*, was noticed, popularly known as "pecky" or "peggy" cypress. Further investigation showed that the defect was prevalent wherever the cypress grew in abundance, and that fungus threads were constantly associated with the pecky wood. This led to the investigations here recorded.

In pursuing these investigations little could have been done without the generous assistance of numerous lumber companies. Among those to whom thanks are due are the Lutcher & Moore Cypress Lumber Co. of Lutcher, La.; Mr. M. E. Leming of Cape Girardeau, Mo.; Towle Bros. of Towle, Placer Co., Cal.; the Stimson Mill Co. of Ballard, Wash.; Mr. A. J. Johnson of Astoria, Oregon, and Birce & Smart of Emigrant Gap, Cal.

To Dr. W. G. Farlow and Dr. H. W. Harkness I am indebted for many suggestions; to Dr. J. J. Früh of Zürich, for his courtesy in answering some questions; to Maj. B. M. Harrod of New Orleans for assistance in obtaining buried cypress logs, and to Prof. C. R. Sanger and Dr. G. Alleman for suggestions on chemical questions. I also take pleasure in expressing thanks to Dr. Wm. Trelease for much encouragement and generous assistance.

THE DISEASE OF TAXODIUM KNOWN AS "PECKY" CYPRESS.

Historical.

The first mention of the disease of cypress known as "pecky," or "peggy" cypress, is made by Dickeson & Brown.* They say of it: "That species of decay to which it [the cypress] is most liable, shows itself in partial or detached spots at greater or less distance, but often in very close proximity to each other. It is a decomposition of the

* Dickeson, Montroville W., & And. Brown. On the cypress timber of Mississippi and Louisiana. (Am. Journ. of Science. ii. 5 : 15. 1848.)

wood fiber to which the tops and central parts are the most exposed, and which, when affected, appear as if operated upon by worms. . . . Timber affected in this way is denominated by raftsmen, '*pecky*.'"

Sargent * says of the cypress: "It is often injured, especially west of the Mississippi river, by a species of *Daedalea* not yet determined, rendering it unfit for lumber." Farlow,† writing in Sargent's Silva, notes that "a species of dry rot in living timber often diminishes its value, and in Louisiana and Mississippi is said to affect at least one-third of all the trees." Rather recently Roth ‡ mentions its occurrence in the South, and briefly describes its appearance. Beyond these few notes, nothing appears to have been said of the disease.

Occurrence.

Taxodium distichum is now found from South Carolina to Florida (some trees occur as far north as New Jersey §) thence to Louisiana and northward as far as southern Indiana ¶ and southeast Missouri. Wherever the cypress grows to any size, it shows the "pecky" disease, the prevalence of which appears to be very variable. The exact percentage is difficult to ascertain as it varies materially with the locality. Roth (l. c.) says that 30% of the entire cypress supply is damaged by this disease. As a rule one may say that wherever the cypress grows, one will find it "pecky," and that there are no regions where all trees are sound. As for particular localities, Roth mentions a tract of land in Florida, which had to be abandoned entirely on account of "pegginess." In the Mississippi Valley by actual count it

* Sargent, C. S. Forest trees of North America. 10th Census 9: 184. 1883.

† Sargent, C. S. Silva of North America 10: 150. 1896.

‡ Roth, Filibert. Progress in timber physics — "Bald cypress." (U. S. Dept. of Agr., Div. of Forestry, Circular No. 19: 3. 1898.)

§ Hollick, A. (Cypress in N. J., read before Bot. Soc. Am. 1898.)

¶ Wright, John S. — Notes on cypress swamps in Knox Co., Indiana. (Proc. Ind. Acad. Sci. 1897: 172).

has been found that the trees near their northern limit are less frequently diseased than the more southern ones. As it is almost impossible to tell whether a tree be pecky or not before it is cut down, all actual counts had to be made where lumber mills were cutting the trees, and as they usually cut all trees, even those liable to be diseased, a fair estimate for that particular locality could be made. In St. James Parish, Louisiana, 397 trees out of 400 were found diseased to a greater or less extent. From circulars sent to various lumber concerns the following estimates are made, which may be considered as much under- rather than overdrawn. Apalachicola, Fla., 10–15%. New Orleans Cypress Lumber Co., 99%. Ramos, La., 15%. Georgetown, S.C., "considerable." These figures refer to "peckiness" in logs used for lumber, and do not have any reference to the tops of trees, which are the first parts to be "pecky." The character of the ground seems to have little if any effect on the prevalence or extent of the disease. The cypress trees normally grow with their root system in water for at least a part of each year, and in many places, particularly along the coast, during the entire year. This rather unusual habit of growth together with the appearance of the puzzling formation of knees has led many to connect the facts of growing in water, development of knees, and "peckiness." So far no evidence is forthcoming to show any connection between these factors.

Name.

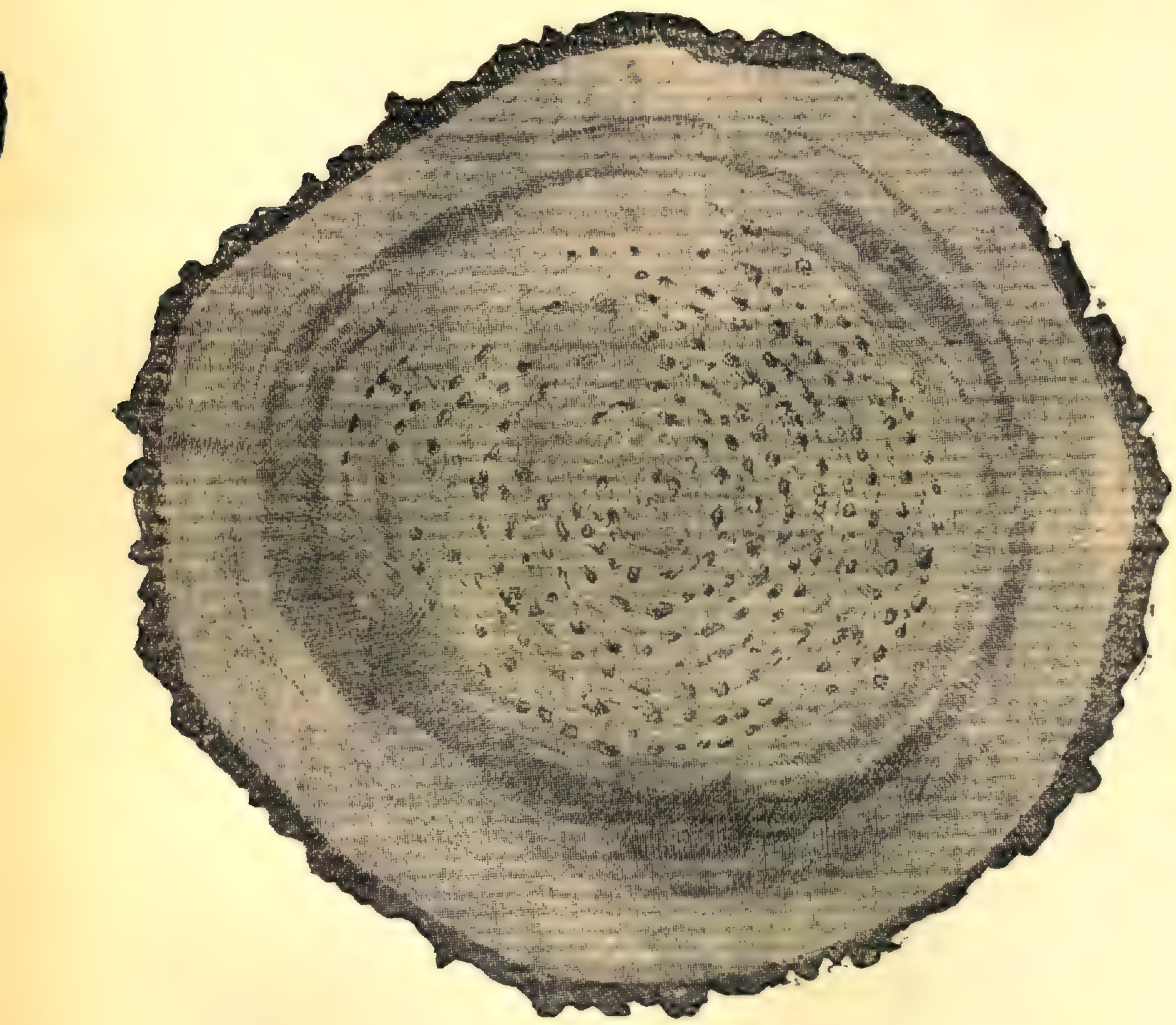
When a diseased cypress tree is cut down, the heart wood appears as if a large number of holes had been bored with a $\frac{1}{4}$ inch bit which had been withdrawn, leaving the shavings, finely divided, within the hole. It is this peculiar appearance which has given rise to the different popular terms applied to the disease. Dickeson & Brown (l. c.) refer to it as "pecky." In the Mississippi Valley and throughout Louisiana I have found the diseased wood called "pecky"

cypress, and the disease itself called the "peck." In North Carolina the term "botty" (see Roth l. c.) is more or less common because of the supposed action of a larva, the "bot." "Peggy" is frequently used in Georgia and Florida, where correspondents also give the term "puck." Near pinelands "punk" is used by pine lumbermen, accustomed to the decay caused by *Trametes Pini*. It is almost useless to speculate as to the origin of the various terms, and a choice between them is difficult. Having found the term "pecky" most widely known as well as the one which was first used, I shall call the disease by that name throughout this paper.

Appearance of Wood.

The diseased wood appears full of holes (Pl. 1, fig. 2), varying in width from $\frac{1}{4}$–$\frac{3}{4}$ inches. These holes are found in the heartwood only, and in trees after they have reached the age of 125 years or thereabouts. Young trees of *Taxodium* are comparatively rare, but such as were noted, varying in age from 50 to 125 years, were always free from any defect. The holes in the wood extend longitudinally up and down in the trunk, parallel to the wood fibers. The holes never extend transversely. They are separated from one another by layers of wood apparently perfectly sound. They vary in length from $\frac{1}{4}$ inch to 6 inches, or longer in some cases; most frequently they are 4–5 inches long. They end bluntly at both ends, and as a rule do not communicate. Frequently trees are found in which some holes do open into one another, but these are rather exceptional. The holes are filled with a yellow brown powder which readily crumbles into the finest dust between the fingers. The powdery mass does not completely fill the space, showing that much material has been destroyed. Occasionally the mass is not entirely composed of the powdery substance; stringy fibers, composed of wood cells not yet disintegrated, fill the cavity, together with much finely divided matter. This indicates that the disintegrat-

ing factor has not acted uniformly but has caused certain parts to decay, while others are spared. A fluffy white fungus mycelium, covered with drops of liquid as with dew, is oftentimes present, but more often none is to be seen amid the dry contents of the holes. Several trees



APPEARANCE OF WOOD.

were found near Mobile, Ala., in which the holes were partially filled with a peculiar reddish-brown, soft substance having a bright shining fracture. This substance adhered firmly to the walls, as if forming a part of the wood fibers. It will be described more in detail. Associated with this substance peculiar white needle-shaped

crystals were found whose identity has not yet been determined, as the amount found was too small to admit of analysis. This substance had the following properties: very light, like fine cotton wool, or cocoon silk, apparently very pure; volatilizes at once on platinum (heated) without burning; insoluble in water, soluble in hot alcohol, from which it crystallizes in shapes looking like sea moss; very soluble in petroleum ether, and extremely so in chloroform; residue colloid, resinous; melting point 174° C., pretty sharp without decomposition; chloroform solution does not absorb bromine; sublimes very readily, forming beautiful hairlike crystals.

A number of trees were found in which the holes, instead of being filled as stated above, were nearly empty. They had a shining white lining (Pl. 4, fig. 3) from which isolated white fibers projected into the cavity. The white fibers were found to be pure cellulose.

When the brown contents are brushed out of the holes a perfectly even and smooth surface is left on all sides, indicating a very sharp dividing line between the decayed elements and those apparently sound. A board from which the powder has been taken looks as if a number of grooves had been cut with a gouge chisel (Pl. 6).

In a tree the peckiness starts in the upper part, i. e., the majority of the trees are perfectly sound at the base, and very much diseased in the upper portion of the trunk and the larger branches. The decay may extend but a few inches up and down, or for several feet, or through the entire length of the tree. The youngest branches in which any peckiness was found were 60 years old. Radially it may appear over the entire cross-section or on but one side. It is by no means the rule that the innermost rings are the first ones to decay (Pl. 1) as might be supposed from analogy with other timber diseases. A large tree at Arbor, Mo., approximately 300 years old, was pecky to within 25 ft. of the base, another to within 35 ft. The

peckiness in the latter extended upward into two main branches for 20 ft. At the points where all recognizable traces of the disease ceased, the branches had about 150 annual rings. A third tree was sound for 60 ft. from the base, then became very pecky, the peckiness passing up into two or three main branches, and still another was pecky 3 ft. from the base and upward. The extent of peckiness varies, i. e., in one trunk the holes may be several inches apart, or scattered all over the cross-section, in another they may be confined to the first 150 rings. Nowhere was a single tree seen hollow, at least none which was hollow because of an advanced stage of peckiness. In this respect this disease affects the cypress just as *Trametes Pini* does the pines. One never finds a pine hollow because of disintegration caused by *Trametes Pini*. This is especially to be noted, as it will be referred to again. It is a noticeable fact that in traveling through cypress forests one rarely sees many fallen trees, and where violent windstorms have overthrown any number of trees, these are just as often trees sound at the base as those which are diseased. In the fall the whole tree falls, i. e., the trunk does not break, as do many pines and deciduous trees, in which the entire heartwood may have been destroyed, by such a parasite as *Polyporus sulphureus*. The oldest trees e. g., in which about 1800 rings were counted (southern Louisiana), have the same appearance as those but 200–300 years in age.

Structure of Diseased Wood.

The wood of *Taxodium* is composed of tracheids with one or two rows of pits. The growth rings are rather broad, the summer wood about one-third the width of the spring wood. Resin passages are wholly wanting, and in their stead there are numerous resin cells either scattering or in tangential bands.* The amount of resin in the wood is

* Penhallow, D. P. The generic characters of the N. A. Taxaceae and Coniferae. (Trans. Roy. Soc. Canada ii. 2 : 51. 1896.)

comparatively small. The diseased wood is darker in color than the normal wood, has no tenacity, and when crushed, turns into fine powder. These properties lead one to suspect profound morphological as well as chemical changes. A radial section through a rotted hole and the adjacent sound wood is represented on Pl. 5, fig. 10. The normal wood cells (a) show the constituent lamellae of the cell-wall plainly. The first noticeable change is in the bordered pits, which look as if they were corroded, like starch-grains in process of solution. This appearance is due to drops of resinous oil, which arrange themselves in this peculiar manner (Pl. 5, fig. 3) on the walls and within the cavity of the pit. When treated with turpentine the resin is dissolved and the pits then look smooth. The walls at the same time are perforated in many places by colorless hyphae; no preference is shown for the pits. As one proceeds toward the decayed spot the pits look fragmented; finally peculiar spiral breaks appear extending from the pits and passing upward from left to right. The breaks of two adjacent walls cross one another at the pits (e), the lower one apparently extending from right to left. The whole cell-wall becomes striated, the striae all extending in a spiral line from left to right around the wall. Before long the circular disc of the pit drops out, leaving a hole with jagged outline, which gradually increases in size. The number of breaks in the walls has increased, and finally the whole wall breaks up into innumerable pieces. The wood, when once the disintegration sets in, becomes so very brittle that it is very difficult to get good sections. Imbedding the same in soft paraffine was found very useful. The longitudinal walls grow thinner because of the shrinkage of the middle lamella. This gradually disappears, and gives rise to the breaks in the wall already spoken of. The shrinkage and solution finally has gone so far that only the primary lamella is left, which breaks into many pieces. The dropping out of the more resistant walls lining the pits is char-

acteristic, and in preparations of much-decayed wood large numbers of the circular discs can be seen floating about.

The micro-chemical reactions are marked. Any investigation into the chemical nature of wood substance is apt to be rather unsatisfactory. It is possible to record certain well-marked reactions, but often their true significance will not be apparent, because our knowledge of the complex constituents of wood, and particularly of its decomposition products, is still so very meager.

The most characteristic reaction is the one with phloroglucin and HCl. If a section, preferably a transection of wood cut so as to include the outer portion of the decayed area, and some of the surrounding wood, be treated with this reagent, an appearance such as is represented on Pl. 3, fig. 1, is obtained. The cells of the sound wood i. e., wood in which no recognizable morphological change has taken place, stain dark red purple. The primary lamella stains much deeper (p). Passing to cells further inward (towards the diseased spot) the tertiary lamellae of some cells no longer stain red purple but yellow (d). This yellow coloration increases as one passes on, the red decreasing correspondingly, until at a certain stage only the primary lamella is stained red. The pits are the first areas to show the yellow color. On a radial longitudinal section the contrast between the surrounding wall and the pit is very marked, the latter looking like a hole in a red field. In the final stage the remaining parts are entirely yellow, no red being visible. The yellow coloration appears first along the medullary rays, and is always in advance of the same reaction in the intervening wood cells. Hand in hand with the disappearance of the red color goes the shrinkage of the secondary lamella, as described. This reaction of the cell-wall is due to the gradual extraction of the coniferin elements of the walls. They are at first extracted from the innermost lamella, then from the secondary lamella, and last of all from the primary

lamella and the intercellular substance at the angles of the cells. If a similar section is treated with chlor-iodide of zinc the walls of sound wood cells are colored yellow-brown. The cells from which the lignin elements have been removed stain brown likewise. This indicates that they are not cellulose. In this respect the disintegration of the cypress wood differs from that caused in wood of the yellow pine by *Trametes Pini*. In the latter there is one form of disintegration in which the lignin elements are gradually removed from the cell-wall, beginning with the secondary lamella, closely followed by the tertiary lamella. After this extraction a much thinner wall of pure cellulose remains. Some cases were found in wood of *Pinus echinata*, however, which could not be distinguished from pecky cypress, i. e., after the extraction of the lignin elements, as indicated by phloroglucin and hydrochloric acid, a membrane remains which is not cellulose. Hartig* describes a reaction much like the foregoing one in pine wood attacked by *Merulius lachrymans*, of which he says: "It appears as if there were a certain relation between the coniferin content of the cell-wall and the ease with which the wood is destroyed." This test is so delicate that it shows the presence of a disturbing cause in the wood long before any evidence can be detected by the microscope. Other lignin reagents give similar results, although not so striking. Aniline sulfate turns sound wood brilliant yellow, while it leaves the affected lamellae almost colorless. Thallin and phenol give similar reactions. If the sections are treated with dilute KOH the normal wood cells are not affected beyond very slight swelling. The diseased cells swell more or less, particularly those parts which stained yellow with phloroglucin. After prolonged action of KOH, the delignified parts stain blue with chlor-iodide of zinc. This indicates that the first change in the

* Hartig, R. Der ächte Hausschwamm 53. Berlin. 1885.

cell-wall is the removal of some of the incrusting substances, probably coniferin and vanillin. The KOH removes the remaining substances and leaves the cellulose membrane free to react with chloriodide of zinc. Very much rotted wood stains intensely blue after treatment with KOH. The blue color appears first about the pits, and diffuses towards all sides, looking much like an inkspot on which water has been dropped, causing it to diffuse irregularly over the surrounding area. Sound wood stains yellow-brown with chloriodide of zinc, even after treatment with KOH. With iodine and sulphuric acid, rotted wood stains brown.

A very different form of disintegration now and then occurs (Pl. 4, fig. 3). What the reason is why one form occurs at one time and a second at some other time, I cannot explain. Large holes appear in the sound wood, filled with a spongy mass of white fibers. The holes have a white or tawny lining of fibers, which can be pulled off in groups. These holes are as large as the ones filled with brown powder. The change in the wood cells is almost exactly like that found in pine wood attacked by *Trametes Pini*,* above described. The secondary lamella is gradually changed so that it stains purple with chloriodide of zinc, that is, the lignin substances have been entirely removed. Very soon after the first signs of delignification become evident, the primary lamella separates into two lamellae, which are then dissolved. This causes the individual wood cells, or rather the cellulose fibers, to fall apart. No intermediate steps between the lignified cell-wall and the cellulose wall are to be detected, which gives the impression that the extraction of the lignin elements must take place all at once. The amount of pure cellulose fiber thus found in one hole is surprising. From a hole 3–4 inches long several grams were obtained of many white

* Hartig, R. Zersetzungserscheinungen, etc. 35.

fibers without any impurities whatever. The quantity of wood transformed into cellulose is exceeded only, as far as I know, by that found in diseased wood of *Juniperus*, decayed by *Trametes Pini*, to be described in another paper.

With polarized light, the prisms being crossed, the primary lamella of sound wood appears white, i. e., it is highly refractive; the secondary lamellae are darker. The rotted wood, with the exception of some very minute particles, allows no light to pass. The hypothesis of a crystalline structure of the cell-wall, as advocated by Nägeli, is based largely on its optical properties. Nägeli held that the double refraction indicated a condition of stress in more than one direction. The absence of any refraction in the rotted wood indicates a homogeneous condition, i. e., one in which the stress is equal in all directions. The change from sound wood to the decayed form must have been a profound one to bring about this condition. It has been noted for wood destroyed by *Merulius lachrymans*,* that it separates the white polarized light into blue and yellow parts. Hartig makes no attempt to explain why this should be so. In this connection it may be said that rotted wood of *Libocedrus decurrens*, yet to be described, and wood of *Juniperus Viginiana* destroyed by *Polyporus carneus*, appear dark when viewed with crossed prisms.

Humus Compound.

In the cells immediately surrounding the rotted areas certain parts of the walls are colored dark brown by an apparently homogeneous substance. This occurs in various forms. Most commonly it has numerous cracks and fissures breaking it into many plates, looking much like mud which has dried in the sun (Pl. 4, fig. 4), then again it appears in the form of irregular granules scattered along the walls,

* Hartig, R. Der ächte Hausschwamm 61. Berlin. 1885.

usually more numerous at the lower end of the cells. When KOH is added the whole mass dissolves slowly, melting away like wax; the tracheids become filled with the red-brown solution. By treating finely divided wood with dilute KOH this substance can be extracted in quantity. If the potash solution is neutralized with dilute HCl, a red-brown flocculent gelatinous precipitate is formed slowly, which gradually settles to the bottom. When dried it resumes the appearance seen in the tracheids. In mass it is reddish-brown, soft, tasteless and odorless, insoluble in alcohol, ether, chloroform, acetone, turpentine, etc., but very soluble in alkalies, KOH, $NaHPO_4$, etc., and can be reprecipitated from such solutions by acids. Because of its peculiar physical and chemical properties the substance is classed among the humus compounds. This humus compound, as it will be designated, was evidently at first in a liquid condition, as it fills the cells so evenly. Furthermore, wherever mycelium occurs, this is coated with a layer of the compound, so that the walls of the hyphae look brown and show several contour-lines. Wherever there is any sign of decomposition, there this product appears immediately. It is at first seen in the medullary rays, filling the cells and obscuring their contents so that nothing can be distinguished in the cells. The brown contents of the rays extend out through many annual rings from the initial point of decay. On several occasions trees were found with exceptionally large quantities of this material. In these trees the cavities or holes had a brown powdery mass lying loosely within, but the bounding walls had a thick coating of the brown substance. It was quite soft, broke readily with a shining fracture, was non-elastic and dissolved readily in alkalies, in fact agreed so closely with substance already found in the tracheids as to leave no doubt as to their being one and the same substance. The finding was of value as it was possible to trace the origin of this compound directly, which was not

possible in the majority of cases. Our present knowledge of the humus compounds is at best a meager one. They are generally described * as black bodies, which form in the decay of organic substances, and which occur in soil, peat, etc. They are divided † into three groups (according to their solubilities): 1. Such as are soluble in alcohol and dilute alkalies. 2. Such as are very soluble in alkalies and precipitated by acids as gelatinous bodies insoluble in alcohol. 3. Such as are very soluble in alkalies, precipitated by acids, the precipitate soluble in alcohol. The substance found in the cypress wood belongs evidently to the second class, one to which a large number of products belong, particularly those obtained from peat and decaying vegetable substances.‡

Much has been written on the humus compounds, particularly those found in peat. Mulder,§ Hoppe-Seyler,‖ Griesebach,¶ Senft,** Früh,†† have treated more or less of various compounds. Früh gives the best general account and the following notes are taken from his paper. He says (p. 63): Ulmates and humates, ulmin and humin, ulmic and humic acids in homogeneous masses or in fine particles give a mass which when moist is slightly elastic. In drying these substances contract, become black, shining like glass, hard, and break, with conchoidal fracture. The splinters

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* Beilstein, F. Handbuch der organischen Chemie **1**: 1107. 1893.

† Hoppe-Seyler. Hoppe-Seyler's Zeit. f. phys. Chemie **13**: 1101.

‡ Some of the humus compound was sent Dr. Früh who says of it: "It seems to agree in its properties with ulmic acid, or a calcium salt of the same." Dr. Van Bemmelen of Leiden has kindly undertaken to make a more detailed examination.

§ Mulder, Liebig's Annalen der Chemie (u. Pharmacie) **36**: 343. 1840.

‖ Hoppe-Seyler. l. c.

¶ Griesebach. Über die Bildung des Torfes in den Emsmooren. Göttingen. 1846.

** Senft. Die Humus, Marsch und Torfbildungen. Leipzig. 1862.

†† Früh, J. J. Über Torf und Dopplerit. Zürich. 1883. (Gives long bibliography.)

are yellow-brown at the edges, transparent and soluble in 5% KOH in the form of the acid or as ulmate or humate; humin and ulmin simply swell in 5% KOH. "In the humification yellow-brown places appear on the cell membrane, which can be bleached out with KOH, in the form of ulmin or humate; the remaining cell membrane shows distinct cellulose reaction. Lignified membranes ulmify with difficulty, although wood cells can change completely into peat." Griesebach (l. c.) mentions the transformation of wood of *Erica Tetralix* and *Calluna vulgaris* into ulmin substances. Humic acids have been found in plants, and Früh mentions a number of cases. Thus according to Lucas, Einhof extracted the same from spores of *Agaricus atramentarius*, while he himself obtained one from *Uredo segetum*. Früh isolated humic acid from spores of *Elaphomyces granulatus*.

In the wood of *Taxodium* in which the large masses of humus compound were found the transition from lignin to the humus bodies was very evident. Pl. 3, fig. 2, represents a section made through the border of a hole, after staining with phloroglucin and HCl. At "g" the primary lamella is seen, dark red, indicating the presence of coniferin, etc. In the next row of cells the interior is coated with yellow-brown masses (h) which in the unstained wood contrast beautifully with the almost white cell-wall. These masses are found to be humus substance, readily dissolved by dilute KOH. The phloroglucin stains the secondary lamella. Between this normally lignified portion and the inner humus layer is a layer staining yellow. This is evidently similar to the membrane already described (Pl. 3, fig. 1 "d"), i. e. the wood substance gives neither a lignin nor a cellulose reaction. After treatment with KOH it stains deep blue. This is in part the process as described by Früh, except that here there is an intervening step between the lignin and the humus substance. Passing now from the cells just described, one finds the layer

of humus increasing in width (c). In drying, numerous fissures have appeared in the mass. The lignin layer becomes narrower and narrower, then disappears and at last even the primary lamella no longer gives the lignin reaction, and the whole is transformed into humus compound (e). The positions of the original cells are still very evident, and here and there a piece (u) of unchanged cell-wall remains in the homogeneous mass of matter.

The action of the rotted membranes on polarized light has already been mentioned. The primary lamella shows decided light lines in a transection of the kind shown on Pl. 3, fig. 2, but as soon as the wood no longer gives the lignin reaction it appears dark when the Nicol prisms are crossed. The same is true of the humus compound. Whatever the change is which changes a non-homogeneous body to a homogeneous one, it is one which takes place when the chemical structure of the non-homogeneous body begins to change. When a portion of the humus mass is dissolved in dilute KOH there appear in the center of this mass certain highly refractive bodies $\frac{1}{2}$–$1\frac{1}{2}$ μ in diameter, of very definite structure resembling human blood corpuscles somewhat (Pl. 5, fig. 8). They are hexagonal in shape with blunted corners and have a much depressed center, so that the edge view shows four contour lines, two parallel lines, and two of an hour-glass shape. When examined with polarized light they shine brightly when viewed from the edge, and as they have a decided Brownian motion, they alternately flash and disappear. Their very variable size, but constant form, as well as their appearance in polarized light, suggest that they are crystals of some sort. Hartig * says that the comparatively high resistance of the walls bounding the lens-shaped pits, is probably due to the large number of calcium oxalate crystals imbedded in these walls; he indicates these by fine dots (fig. 13). The

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* Hartig, R. Der ächte Hausschwamm 57

small bodies which he finds he describes as "rounded in form." He suggests that they may be crystalline, and that the deposition of the lime in the walls is made in the form of crystals. "If this be true it may be asked whether the action of the cell-wall when viewed with polarized light may not be explained by the refraction of these bodies." Hartig, however, did not prove the crystalline nature of the bodies. The small bodies from the humus compound dissolve in HCl, which might indicate them to be crystals of calcium oxalate. They are evidently massed together in the humus compound, and become visible only when the latter is removed. It is not at all improbable that they were constituents of the cell-wall, which were not destroyed by the disintegrating factor and remained unharmed, imbedded in the liquid mass of humus compound. The present data do not warrant any definite conclusions as to their real nature and origin.

From the description just given of the formation of the humus compound, and comparing this with the normal method of disintegration of the wood, it seems that the process may be summed up as follows: For some reason, the normal lignified membrane changes, i. e., certain of its constituents, which ordinarily react with phloroglucin, are extracted. Then more profound changes take place ending in the formation of a humus compound. This ordinarily diffuses through the adjoining cells, and ultimately hardens in the tracheids surrounding the rotted area and in the medullary rays. At the same time all contents of the cells, hyphae, starch grains, etc., are covered. Numerous experiments were made to determine the approximate per cent. of matter soluble in dilute KOH, both in much rotted wood and in wood immediately surrounding the holes, apparently sound. The amounts were found to vary between wide limits. On an average about 34% was obtained from much rotted wood, the remaining 66% consisting of pieces of wood fibres not transformed. In the wood immediately surrounding

the holes 6–8% was obtained. The soluble matter was precipitated from the 2% KOH solution with dilute HCl and dried at 100° C.

Wood Between the Rotted Areas.

The wood between the holes is darker in color than the normal wood, but cannot be distinguished from it structurally. Numerous fungus threads pass through the walls or have punctured them in many places. Near the holes much of the humus compound occurs, and many of the pits show the peculiar arrangement of oil globules. The specific gravity of sound heart wood and that of the wood between the holes, was determined by weighing blocks and measuring them. As the plates of wood between the holes as a rule are but $\frac{1}{2}$-$\frac{3}{4}$ inch wide, and the mass of wood not occupied by holes but $\frac{1}{2}$ inch long, the pieces to be measured had to be rather small. To bring the two tests under similar conditions, the blocks from normal wood were made of similar size. The blocks were dried at 100° C. until approximately constant weight was reached. The specific gravity of sound wood was found to be .508; that of the other, .401. These figures are probably only relatively correct, but as each is the average of a number of blocks, they seem to show that even if no visible change has taken place in the wood between the holes, some change must have occurred, otherwise there would not have been so great a difference in specific gravity. Very pecky cypress planks which had been exposed in lumber yards for many years, were examined. The powder and wood fibers which had filled the holes had been washed out and had left a smooth, even surface. The wood was to all intents and purposes very sound, and no change except numerous perforations in the walls, and the presence of much humus compound, could be detected.

It is this property of the pecky cypress not to pass beyond a certain stage of decay, which has made it possible for the wood to be utilized in a variety of ways. Dickeson & Brown call attention to this fact: "There is this peculiarity of this disease, that the cutting down of the timber arrests its further progress, and timber thus affected, although not as strong, is found to last as long as that which is very sound." This is probably a unique case of specifically "rotten" wood still capable of being used for commercial purposes. The durability of cypress timber is universally admitted, and pecky cypress does not seem to be much less so. Where it is, as in this case, a question of dollars and cents, the testimony of practical lumbermen is especially valuable. Thus, whereas sound cypress lumber sells for $20–$25 per 1,000 ft. B.M., pecky cypress sells for $5–$10 per 1,000 ft. B.M.; generally from $5–$8. One firm makes two grades of pecky planks: "pecky," and "dangerously pecky;" "the latter means that the holes are so large that a mule might put his foot through"! Mr. G. M. Bowie, of Whitecastle, La., writes: "I am watching some pecky planks laid on the ground, exposed to rain and sun; they are unchanged so far in ten years." Throughout the Southern States pecky cypress boards are used for bridge planking on plantations, for siding, sidewalks, flooring, culverts, foundations under brick work, in wet places, etc. Mr. A. S. Mohr, of Apalachicola, Fla., says: "We use pecky planks 2 in. thick and upwards for making driveways, wharfs, tramways, and for such purposes it is invaluable."

In Mobile, for instance, where there are open ditches along many streets, the vertical bank, flanking the pavement, and the bottom of the ditch are lined with pecky boards, and their lasting powers seem to be fully equal to sound boards. (Pl. 6.)

For sidewalks, such lumber is used in almost every town or city within the reach of cypress swamps, and when the

softer powder has worn away the grooved boards have a singular appearance.

From such data it may safely be said that the disintegration never goes beyond a certain stage. When a tree is cut down the further progress of the disease is stopped. No tree, as far as is known, has been seen in which all the wood had been destroyed, and it is for this reason that a diseased tree remains standing even when much decayed.

Strength of Cypress Wood.

A number of tests were made to determine the relative crushing strength of sound cypress wood and that of very pecky wood.* In making these tests blocks cut from the heartwood were used. These were dried in a kiln for three days and were tested immediately after being taken from the drying oven. The tests were made with the machinery used for the timber tests of the U. S. Division of Forestry.† A full description of the same will be found in the bulletin referred to.

Crushing Strength (Endwise), of Sound Cypress. (Heartwood.)

No.	Dimensions of block. Inches.	Height. Inches.	Area. Square inches.	Breaking load. Pounds.	Breaking load per square inch. Pounds.	Locality.
1	1.32×1.30	3.24	1.71	12,300	7,191	From Lutcher, La.
2	1.69×1.27	3.23	2.14	15,490	7,144	" " "
3	1.55×1.29	3.00	1.99	14,250	7,160	" " "

* In making these tests I am much indebted to Mr. W. H. Henby for material assistance.

† Timber physics. Pt. I. (Bull. U. S. Div. of Forestry 6: 31.) Washington. 1892.

CRUSHING STRENGTH (ENDWISE), OF PECKY CYPRESS. (HEARTWOOD.)

No.	Dimensions. Inches.	Height. Inches.	Area. Sq. inches	Breaking load. Pounds.	Breaking load per square inch. Pounds.	Character.
1	2.13×3.25	5.98	7.14	35,170	4,925	A little sapwood in one corner. Upper surface showed 4 pecky spots.
2	2.65×3.17	6.87	8.40	43,680	5,200	Near center of tree, 14 holes visible on upper surface.
3	2.92×3.16	6.86	9.23	40,130	4,350	*Very* pecky. 14–18 holes visible on upper and lower surfaces.
4	3.25×3.37	6.55	10.95	56,050	5,120	*Very* pecky. Same appearance as No. 3.
5	3.47×3.52	7.75	12.21	40,850	3,345	*Extremely* pecky.

CRUSHING STRENGTH (ENDWISE), OF PECKY CYPRESS BEFORE DRYING. (HEARTWOOD.)

No.	Dimensions. Inches.	Height. Inches.	Area. Sq. inches	Breaking load. Pounds.	Breaking load per sq. inch. Pounds.	Weight moist Grams.	Weight dry. Grams.	% Moisture.
1	3.03×3.22	4.37	9.75	30,200	3,097	335	278	17.0
2	3.30×3.44	3.06	11.35	35,680	3,143	275	238	13.6
3	3.51×3.55	3.29	12.46	35,970	2,886	287	261	9.0

In these tables but a few tests are given: a more extensive list is in preparation. A glance at these tables will show how comparatively strong the very pecky wood is, which is a rather surprising feature. It is of course diffi-

cult to state exactly how pecky a certain piece is, but the samples tested were considered as fair averages of the grade generally used for sidewalks, etc. The block marked 5 was very much more pecky than the others. From the third table it appears that when wet the wood is less strong than when thoroughly dry, which is true of all woods. The breaking of the pecky blocks was almost without reference to the holes. The wood between the holes had to stand the load, and that it was capable of holding up as much as it did is another proof of its comparative soundness. The number of tests made so far is as yet too small to determine whether any relation exists between the absolute weight of wood fiber present in the pecky logs and the breaking strength.

Mycelium.

Within the holes, and throughout the heartwood of a diseased tree, the mycelium of some fungus is constantly met with. This is present but sparingly, and rarely forms extended masses or felts. In spite of extensive and searching examinations of a very large number of cypress trees for several years, no fruiting organ has yet been met with. The only fungus ever reported was the one mentioned by Sargent * which, as far as can be determined now, had little adequate foundation. Of the other fungi hitherto reported as growing on *Taxodium* none could be brought into any causal connection with the mycelium always found in the tree. It is to be hoped that before long the fruiting form may be discovered.

The disintegration of the wood is, in many respects, like that brought about by *Trametes Pini*, but so far there is no evidence to prove that this is the fungus which causes the "peckiness."

Wherever there is any sign of decay in the cypress wood,

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* Sargent, C. S. Forest trees of N. A. 10th Census 9 : 184.

a distinct mycelium is present, and the probabilities are strong that it is the one which brings about the decay of the wood. The hyphae are brownish when young, but soon become colorless. Their chief and striking characteristic is the presence of very many clamp connections (Pl. 5, fig. 1). Brefeld,* Hartig,† and others have shown that these organs are to be found among the Basidiomycetes, particularly among the *Agaricineae* and *Polyporei*. Brefeld (l. c.) describes their formation in *Coprinus stercorarius* as lateral outgrowths of one cell fusing with the cell beneath it, and then forming a separating wall. At such points numerous branches usually appeared. Hartig (l. c.) describes the clamp connections of *Merulius lachrymans*. In this fungus they bud out, and form a branch, sometimes before the separating wall in the clamp has fused with the next cell. This is a unique case among the Hymenomycetes, as the clamps are "sterile" in all other forms.

The clamp connections occur on all parts of the mycelium found in *Taxodium*, but in no case did any of them branch as they do in *Merulius*. The mycelium consists of large hyphae with distinct thin walls, and hyphae of smaller diameter. The larger hyphae are constricted at the points where two cells join. They branch frequently, giving rise to the hyphae of smaller diameter. These in turn branch and rebranch. At certain points a short branch is given off which divides very rapidly into the finest threads, of hair-like dimensions. These smaller hyphae penetrate the cell-walls in all directions. Connections between adjacent hyphae occur frequently, also complicated masses, where large numbers of hyphae have fused more or less. As a rule there is but very little mycelium to be found either in the much rotted wood or the intermediate parts. Numerous holes occur all through the wood, indicating where

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* Brefeld, O. Untersuchungen über Schimmelpilze **3**: 16. 1877.

† Hartig, R. Der ächte Hausschwamm 14. *pl. 1, fig. 3.*

the hyphae had passed through the walls. The threads show no preference for the pits. The holes often have the shape of a figure 8, i. e. they enlarge within the secondary lamella, a feature which is common to wood destroyed by many wood-destroying fungi. The scarcity of mycelium is striking, resembling in this respect wood in which *Polyporus sulphureus* has been growing.* In branches where the disease is in its youngest stage, the mycelium occurs more plentifully in those areas, which correspond to the holes to be formed later on. Between these areas the hyphae pass, boring through the tangential walls.

Besides the colorless mycelium, a mycelium is often present in the wood between the decayed holes. This appears to belong to some saprophyte, which has nothing to do with the original decomposition. This mycelium is composed of brown threads which pass through the tangential walls preferably and follow the direction of the tracheids up and down. These hyphae form marked attachment organs when boring through the cell-walls. Frank† described such organs as formed by the germ tubes of *Fusicladium tremulae*. The hypha when it touches the epidermis forms a swelling with one or more pores, from which fine tubes push through the walls into the epidermal cells. He called the swollen parts "Appressorien" or attachment organs, and believed that they aided the hypha in puncturing the wall. De Bary ‡ found similar organs in germ tubes of *Peziza Sclerotiorum;* these were formed "owing to a mechanical stimulus, which the resistance of a solid body exerts on the hyphal branches." Büsgen § described the

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* Hartig, R. Zersetzungserscheinungen des Holzes 110.

† Frank, B. Über einige neue u. weniger bekannte Pflanzenkrankheiten. (Ber. d. deut. bot. Ges. **1**: 30. 1883.)

‡ De Bary, A. Über einige Sclerotinien u. Sclerotienkrankheiten. (Bot. Zeit. **44**: 377. 1886.)

§ Büsgen, M. Über einige Eigenschaften der Keimlinge parasitische Pilze. (Bot. Zg. **51**: 53. 1893.)

attachment organs as smaller portions of a hypha, formed as a result of contact or pressure irritation. "These organs adhere very closely to the cell-walls and in that way probably act as braces to give the penetrating hypha an opportunity to exert the mechanical pressure necessary to penetrate the cell-wall." Miyoshi * found that in order to penetrate a wall "the fixation of the hypha was absolutely essential" and explains the formation of attachment organs as tending in that direction. Hartig † figures several cases of swollen hyphae in the mycelium of *Polyporus vaporarius*.

The penetration of the cell-wall is brought about, according to Brefeld,‡ Büsgen (l. c.), Miyoshi (l. c.), Ward, § and others by the chemical action of a ferment given off by the tip of the hypha, aided by pressure. In the diseased wood of *Taxodium* the brown hyphae pass through the cell-walls of the wood fibers of both spring and summer wood in a radial direction. The path of a hypha is made up of a succession of short curves, each within the lumen of a wood cell (Pl. 4, fig. 1). When the tip of a hypha touches the wall it is deflected considerably, as if the hypha were pressing against the wall and pushing along the same. At the same time the tip swells, and a thread of much smaller diameter pushes into the wall. Sometimes there may be two such threads (Pl. 5, fig. 9). When they have passed through the wall they enlarge to the former size of the hypha, and grow on through the next cell, to be deflected as before upon reaching the opposite wall. On Pl. 5, fig. 9, a number of these attachment organs are represented, occurring in the wood of *Taxodium*, and also

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* Miyoshi, Manabu. Die Durchbohrung von Membranen durch Pilzfäden. (Pringsh., Jahrb. f. wiss. Bot. **28**: 269. 1895).—Über Chemotropismus der Pilze. (Bot. Zg. **52**: 1. 1894.)

† Hartig, R. Zersetzungserscheinungen, etc. *pl. 8. fig. 11.*

‡ Brefeld, O. Untersuchungen über Schimmelpilze **4**: 112. *f. 11, 15.*

§ Marshall-Ward, H. On a lily disease. (Ann. Botany **2**: 319. 1889.)

in diseased wood of *Libocedrus decurrens*. At a one of the attachment organs has formed a branch. These organs adhere very firmly to the walls against which they are pressed; from the curved form of the hypha one is led to suppose that the pressure exerted by the hypha must be considerable. The reason for supposing these brown hyphae to be saprophytic is that they are usually found somewhere in the wood near a knot hole, where there is abundant opportunity for the entrance of saprophytes.

In many cases a form of mycelium with very thick walls occurs. This has few clamp connections and forms thick felts in the holes. This was found only in logs after they had been cut, so there is some reason for considering it as foreign to the disease. The great age of many of the cypress trees, and the consequent presence of numerous places where branches have been broken off, allows many fungi to get in which live on the dead and decaying wood, but which seem to have nothing to do with the peckiness. Their presence makes the study a difficult one at times, especially as they seem to grow rapidly and fructify readily. Thus a number of spore forms were met with, but in no case could these be brought into any connection with the colorless mycelium. One form was found very often (Pl. 5, fig. 5) also frequently present in diseased wood of *Libocedrus decurrens* and *Juniperus Virginiana*. The spores are almost round, about 1 μ in diameter, brown, with a distinct wall and a central shining body which is not affected by reagents. Many of the spores have short knobs. The spores occur in such numbers in the wood around the holes that it seems probable that they were formed in chains and may be considered chlamydospores. A number of times chains of two or three were found with fine remnants of hyphae attached. These spores were placed in cultures of dung, cypress agar, and gelatin, but have so far refused to germinate. It is possible that they represent some form of entophytic organism (*Chytridiaceae ? Phytomyxae?*) studied by

Fischer, Dangeard, De Wildeman and others. Brefeld * records an instance of similar spores in *Peziza tuberosa*. These were constricted off in chains and refused to germinate. Hartig † found spores in wood destroyed by *Polyporus sulphureus*. These, he says, belong to some saprophytic fungus, always found with *Polyporus sulphureus*. In wood of *Quercus alba* and *Q. nigra* destroyed by *Polyporus sulphureus*, collected in New York and Arkansas, similar spores were found, represented on Pl. 5, fig. 8, for comparison. They seem to be constantly present wherever *Polyporus sulphureus* has destroyed oak wood. The association of these two fungi is not understood as yet, and awaits further investigation.

Besides the brown spores a number of others occur, a few of which may be mentioned. One form, large, black spores in chains, resembles Willkomm's ‡ *Xenodochus ligniperda* (Pl. 5, fig. 7). Another form, consisting of large two-celled chlamydospores (Pl. 5, fig. 4), is not infrequent.

Progress of the Disease.

In the early stages of the disease the wood turns yellow in localized areas, about $\frac{1}{4}$ inch wide and extending longitudinally with the wood fibers for several inches (Pl. 1, fig. 1). These areas are separated by intervening layers of wood, unchanged in color. In the wood cells of the yellow areas numerous hyphae of the colorless mycelium are found. The larger hyphae extend longitudinally through the cells and give off many branches which pass and repass through the walls. The ultimate hairlike branches reach every cell in the area. Numerous clamp connections are to be seen. Between the yellow areas the hyphae extend through the wood cells, passing through the

* Brefeld, O. Bot. Untersuchungen über Schimmelpilze **4**: 113.

† Hartig, R. Zersetzungserscheinungen, etc. 113. *pl. 14. f. 10–12.*

‡ Willkomm, M. Die mikroscopischen Feinde des Waldes. *pl. II. f. 8.* 1866.

walls radially to another yellow area at that height or longitudinally to one above. Immediately around the yellow areas it looks as if the hyphae were passing through this wood as rapidly as possible. As the disease progresses the mycelium can be found only sparingly in the yellow areas and in the surrounding wood. Their former presence is indicated by the numerous holes in the walls.

From the facts presented, it seems that the growth of the fungus is about as follows: The mycelium starts at some point in the heart-wood where it flourishes in a limited area for some time. Some of the threads then grow out from this area (which is limited, for some reason or other), and grow both transversely and longitudinally from the original center. At points some distance from this center new centers are established, which in time are limited and form starting-points for further growth. One may cut through a young branch and find the cut surface perfectly sound. On splitting both pieces of the branch, one may find that at points several inches above the cut one or more distinct yellow areas are present, and the same may be true of the piece below the cut. In the wood between, numerous hyphae occur, which, however, do not spread in this wood. The areas where vigorous development has taken place ultimately become holes, and the tree then appears as already described, i. e., sound wood filled with lens-shaped cavities. The original hyphae are gradually absorbed, so that after a time the figure-8 holes in the walls are the only evidence of their former presence.

The path of the mycelium is always the shortest distance from hole to hole. This apparent avoidance of the wood between holes — an apparent preservation — is very striking. It is suggested that this is probably due to chemical influences which affect the hyphae in this manner. All attempts to grow the mycelium have so far failed. Media were prepared from decoctions of cypress wood and carefully titrated; they were then inoculated with fresh myce-

lium, which, however, did not grow. Fresh pecky wood has been kept in moist chambers now for almost three years without any sign of growth. Further experiments are in progress.

Propagation of Disease.

The constant presence of the colorless mycelium in diseased trees makes it seem probable that this is the vegetative part of a fungus which causes the decay. As has been said, no fruiting organ has yet been found, so the manner in which this disease is carried from tree to tree is still to be discovered. A large number of logs were split open, and in some of these, large places were occasionally met with where an old branch had been healed over, leaving a cavity. In this cavity dense white felts of the mycelium, in which numerous crystals of calcium oxalate were imbedded, were obtained. There was, however, no sign of a fruiting organ. In some boards beginnings of such felts were found but none of these have developed any further. Reasoning by analogy from the diseases of trees already known we ought to find at some time a pileus of some sort. That infection takes place through a broken branch or some part of the top of the tree is most probable. Many trees were cut down in which the "peck" could be traced directly to a broken branch, extending up and down from this point. This was especially marked where, as in a number of instances, the "peck" was confined to one side of a tree.

Localization of Disease.

The most characteristic feature in connection with this disease, distinguishing it from others so far described, is its peculiar localization, i. e., the destruction of the wood in distinctly localized areas. The formation of the holes has been described, and it has been noted that the contrast between diseased areas and sound wood is a marked one,

furthermore that fungus threads occur all through a given section of a tree.

The manner in which fungi influence their hosts varies considerably. One may consider the distribution of the mycelium within the host. There are but few references to this point in discussions on fungi. Tubeuf * says: "A large number of fungi have a mycelium which never extends beyond a very short distance round the point of first infection, and cause only local disease, frequently with no perceptible disturbing effect on the host. Such is the case with leafspot diseases." Thus Frank † describes the mycelium of *Gloeosporium Lindemuthianum* as causing a browning of the tissues as far as the mycelium extends. The same is true of *Cercospora*. The mycelium of *Aecidium Rhamni* on *Rhamnus frangula* has a local distribution,‡ so also that of many Erysipheae, for instance *Microsphaera densissima* also *Uncinula necator* of which an interesting case was recently described by Stevens.§ This localization of the mycelium may be due to mechanical obstructions, such as the veins of a leaf, as in *Puccinia Podophylli*, or to chemical reaction on the part of the host. The large majority of fungi have a mycelium which extends through large areas of their hosts. Wakker (l. c.) classifies parasitic fungi according to their effects on their hosts as producing either mechanical or chemical effects. By mechanical effects he understands such as are due to direct pressure. The vast majority affect their hosts chemically. Here again two classes may be distinguished, such as produce chemical effects "which will immediately, or otherwise exert a direct destructive influence

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* Tubeuf, C. Freiherr von. Diseases of plants 16. (Eng. edit.)

† Frank, B. Über einige neue u. weniger bekannte Pflanzenkrankheiten. (Ber. d. deut. bot. Ges. **1**: 31. 1883.)

‡ Wakker, J. H. Untersuchungen über den Einfluss parasitischer Pilze auf ihre Nährpflanzen. (Prings., Jahrb. f. w. Bot. **24**: 505. 1892.)

§ Stevens, F. L. A peculiar case of spore distribution. (Bot. Gaz. **27**: 138. 1899.)

on their hosts and those which live for a longer or shorter period with their host without producing such effect.''* To the first class belong all such plants as produce immediate death, like *Peronospora*, *Agaricus melleus* and many *Polyporei*, and those producing hypertrophies, such as *Gymnosporangium*, *Exoascus*, and others. To the second class belong many *Uredineae* and *Ustilagineae*, *Exobasidium*, etc. In the latter cases the mycelium may live for a long period in the cells without any perceptible effect on them. The reason for this "conservation" (Tubeuf, l. c.) is doubtless to be sought in complex chemical conditions which bring about one kind of effect with one, and another with a different fungus.

In all the cases just mentioned, one is dealing with living tissues capable of reaction of some sort. This reaction may take the form of starch accumulation, hypertrophied structures or the formation of products antagonistic to the growth of the invading fungus. The bacteria are a good example of organisms bringing about the last form of reaction, i. e., where the host produces substances which neutralize the poisonous products formed by the parasite. To what extent similar processes take place in plant cells is yet unknown, but there seems to be no reason why they should not.

In the heartwood of a tree one is dealing with a plant member to all intents and purposes dead, i. e., its power to react to any stimulus has been lost, so that such influences as would affect the distribution as well as chemical activities of a mycelium in a living member can have no bearing here. There is in the *Taxodium* a marked localization, and, as will be shown, this is also present in *Libocedrus decurrens*, *Juniperus Virginiana*, *J. Bermudiensis*, and to some extent in pines attacked by several of the *Polyporei*.

The localization of chemical action, for such the disinte-

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* Tubeuf, C. Freiherr von. Diseases of plants 21.

grating action on wood must be, cannot be due to mechanical causes, such as difference in the character of the wood cells, or the presence of obstructing layers. In the first place all wood cells are disintegrated, whether they be of the spring or summer wood, and the bounding lines of a cavity are not influenced by the harder summer wood as might be supposed. Then again no resistant layers, as such, excepting the harder summer wood, exist in the heartwood. The isolated resin cells seem to have no bearing in this connection. The only remaining explanation is to attribute the local decay to chemical influences, which prevent the decay from spreading beyond well-defined limits.

It is a well-known fact that certain kinds of wood are more durable, i. e., resist the destructive influences of fungi longer than others. Willows, for instance, are more easily destroyed than oaks or cedar. Frank * and Temme † have shown that in dicotyledonous trees a certain preservative gum is found. This is formed in all wounds open to the air, and occurs normally in all heartwood. This wound gum fills the vessels similarly to thylloses, and renders them impassable to air and water. The wound gum is insoluble in alcohol, ether, H_2SO_4, KOH, but soluble in hot HNO_3. These authors do not explain what causes the formation of this preservative material, beyond the fact that it forms when healthy wood is wounded and exposed to the air. In the Coniferae this substance is not present and Frank ‡ holds that the infiltration of resin takes the place of the gum. Hartig § finds a yellowish-brown mass in the cells adjacent to wounds in trees. This mass is usually much cracked. He calls it dried brown solution,

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* Frank, B. Über die Gummibildung im Holze u. deren physiologische Bedeutung. (Ber d. deut. bot. Ges. 18 Juli, 1884).

† Temme, F. Über Schutz und Kernholz, seine Bildung u. seine physiologische Bedeutung. (Landw. Jahrb. **14**: 465. *Taf. 6, 7.* 1885.

‡ Frank, B. Die Krankheiten der Pflanzen **1**: 41. 1895.

§ Hartig, R. Zersetzungserscheinungen etc. 66. *pl. 11. fig. 7.*

and believes that it consists of decomposition products of wood exposed to the disintegrating influences of the outer air. These products are dissolved by water and penetrate far into the tree, bringing about the characteristic phenomena of wound rot. Frank * claims that Hartig has mistaken the nature of this substance, which he says is not a humus compound but wound gum, which acts as a preservative. A comparison of Hartig's figure and the one on Pl. 4, fig. 4, will show that in point of appearance the substance described by Hartig and the one in *Taxodium* cells are alike. I have also found such substances in wounds, and neither these nor the substance in *Taxodium* are the wood gum which Frank describes. I believe that Hartig is right when he calls them humus solution, but cannot agree that they are active in promoting decomposition. It might be added that Willkomm † ascribes the brown coloration of diseased pine wood to a humus compound which he says is formed from the cell-walls when they begin to decompose.

No substance corresponding to Frank's wound gum could be obtained from the *Taxodium*. An aqueous extract of the sound wood is yellowish in color, due to some coloring matter akin to curcumin. A number of analyses made of diseased wood failed to give any substances which might be regarded as preservative. The sole difference so far found between the normal wood and the diseased wood was the constant presence of the humus compounds described in the diseased wood.

There are numerous instances which illustrate the preservative and antiseptic properties of humus compounds. The preservative powers of peat deposits are well known. Peat is largely if not entirely composed of humus compounds of one kind or another. Its preservative and antiseptic prop-

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* Frank, B. Krankheiten der Pflanzen 1:32. 1895.

† Die mikroscopischen Feinde des Waldes 68.

erties have been attributed to its humus acids. Thus Stutzer and Burri * killed cholera germs in a quarter of an hour with a decoction of peat. Lyell † speaks of the remains of animals and men, which had been perfectly preserved for many years in peat bogs. Kerner von Marilaun ‡ holds that the preservation of plant parts is brought about in moors by humus acids. "The dead plants are saturated with these acids and are not resolved into carbon dioxide, ammonia and water, but preserve their form and weight. The rapidity of decay varies inversely as the quantity of compounds of humus acids present." Also "the fact that fossil remains of Equisetums, Lycopodiums and Cycads . . . have reached us in such good condition, is explained by the presence of humus acids which are found so universally in peat.§ Ganong ‖ points out that the scarcity of nitrogen in peat bogs is due to the absence of bacteria "caused doubtless by an actively antiseptic quality of the bog water." Trees and stumps have often been found in bogs perfectly preserved. Lyell (l. c.) speaks of tree-trunks dug out of Irish bogs and used for masts, also of white cedar logs in New England bogs.¶ Other instances might be mentioned, but these will suffice to show that the humus compounds have antiseptic and preservative properties.

In the heartwood of the cypress one finds the wood substance being split up and destroyed. The decomposition stops after a time, and the fungus mycelium, which at

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* Stutzer A., u R. Burri. Untersuchungen über die Einwirkung von Torfmull . . . auf die Abtötung der Cholerabakterien. (Zeits. f. Hyg. u. Inf. Krank. **14**: 453. 1893.)

† Lyell, Sir Chas. Principles of geology 722.

‡ Kerner von Marilaun, A. The natural history of plants **1**: 262 (Eng. edit. by F. W. Oliver). 1894.

§ Kerner von Marilaun. l. c. **2**: 612.

‖ Ganong, W. F. Upon raised peat bogs in the province of New Brunswick. (Trans. Roy. Soc. Canada ii. **3**: 131. 1897.)

¶ Lyell, Sir Chas. A second visit to the United States 33. 1850.

first developed profusely, evidently stops growing. The threads become coated with a brown substance, which also fills many of the cells around the area where active decomposition has taken place, and saturates the cell walls. This humus substance is one of a class known to possess antiseptic properties. These facts suggest that the humus compound described above may in part be the agent which limits the disintegrating effects of the fungus.

Origin of the Humus Compound.

The origin of the humus compounds is still a matter of some uncertainty, owing to the intrinsic difficulties. Früh, who probably has paid more attention to this problem than any other investigator, says that we know as little about the successive stages which a plant member passes through, until peat is formed, as we do of the processes which bring about these changes.* The process is essentially a process of decay. It is at present recognized that decay may be due to chemical processes as such, distinguished from those brought about through the agency of living things. Where decay, or more properly a splitting up of highly complex organic compounds into simpler compounds such as carbon dioxide, ammonia and water, takes place without the aid of bacteria or fungi, it is largely a process of oxidation. If access of oxygen is prevented no decay takes place. Hartig,† speaks of the decomposition of plant members following death due to frost, as a process due to the action of oxygen on the dead organic substance; fungus mycelia get into the tissues after a time and hasten this decomposition. Früh‡ distinguishes two forms of decomposition not due to chemical changes per se (such as oxidation); these he calls "Gährung" and "Fermententwicklung."

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* Früh, J. J. Über Torf u. Dopplerit 38.

† Hartig, R. Zersetzungserscheinungen, etc. 65.

‡ Früh, J. J. l. c. 39.

The first process is brought about "through the direct influence of the plasma of a living fungus, and is characterized by an evolution of heat and carbon dioxide. The other form is caused by a ferment excreted by living plants. This distinction can no longer be made to-day, as it seems probable that the first form of decomposition is also due to a ferment. Since humification takes place only under water, Früh holds that one might suppose a ferment the active agent in the formation of peat. But this cannot be true, for, if a ferment were the agent forming peat from vegetable substances, the process of humification would be a uniform one, that is, a given mass would be entirely transformed into peat. In a bog, however, this is not the case, for there are alternate layers, some of which are humified, others not. Früh, therefore, agrees with Einhof who says that "lack of free oxygen, a high degree of moisture and a low temperature, brought about by much moisture, bring about a decomposition of a peculiar kind, i. e., the formation of humus compounds or peat." He sums up as follows: * "The formation of peat is neither due to 'Gährung' nor to a ferment but consists in the slow decomposition of plants, with the greatest possible exclusion of oxygen by water, and at low temperature. Bacteria have nothing to do with the formation of peat." This view of peat formation is the one generally accepted; thus, Shaler † explains it as due to the arrest of disintegration arising from the fact that the oxygen of the air does not have free contact with the carbon, and thus cannot convert it into CO_2.

This explanation practically states the fact that cellulose and lignin do change into a series of humus compounds, and that it is a process of chemical change. It does not explain what that change is and why it should take place.

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* Früh. l. c. 49.

† Shaler, N. S. Peat deposits. (16th Rep. Director U. S. Geol. Survey. 4:308. 1895.)

A number of observers still maintain that fungi or bacteria are active in bringing about humification. Thus Höveler * finds that in the humus of a forest the mycelia of fungi initiate the process of humification. These mycelia are brown in color and are found in every humus soil. They belong to many different fungi and are characterized by possessing clamp connections. *Cladosporium humifaciens* Rostrop, he regards as the form most frequently present.

In decaying trees, and in such as are attacked by various fungi, such humus compounds are frequently present; they have been classed as decomposition products without further statement as to their origin. In decaying masses numerous fungi usually grow all through the mass, which makes it difficult to decide what the true humifying agent is. In the cypress a humus compound usually appears in the cells in which a definite fungus mycelium is growing. The same is true and probably more marked where the mycelium of *Trametes Pini* grows in pine wood. The latter turns red-brown very soon after the mycelium has entered the wood, and examination shows that this color is due to a humus compound. No humus compound is present in sound wood. This behavior of the compound makes it seem probable that the fungus in some way changes the cell-walls, and that the humus compound is one of the direct products of this change.

Ferments.

In the decomposition of wood it has been assumed that ferments take an active part. Enzymes which attack cellulose and lignified membranes are known. De Bary † and

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* Höveler, W. Über die Verwerthung des Humus bei der Ernährung der chlorophyll-führenden Pflanzen. (Prings., Jahrb. für wiss. Bot. **24**: 390. 1892.)

† De Bary, A. Über einige Sclerotinien und Sclerotienkrankheiten. (Bot. Zg. **44**: 377. 1886.)

Marshall-Ward * isolated ferments which corroded cellulose membranes. Brown and Morris † discovered a ferment in germinating barley grains, and Vignal ‡ records a case of a ferment secreted by *Bacillus mesentericus*, dissociating vegetable cells by destroying the middle lamella. The action of the wood-destroying fungi is such, that Hartig and others have attributed the decay which they bring about to some enzyme excreted by the hyphae. That the same fungus produces several such enzymes must follow from the different effects which the same fungus has on the same wood. If then we assume such a cytohydrolytic enzyme to be formed by the *Taxodium* fungus, we find it destroying the wood about a certain center. As the mycelium grows along the vessels more readily than across them, a long hole is formed. As a result of the action of the fungus on the cell-walls, an acid humus compound is formed, which is deposited in the cells surrounding the center of fungus activity. It is not far to make the further assumption that after a time the amount of humus compound would be sufficiently great to stop the further development of the fungus in that area. The hyphae however pass through this area to a new center, where they begin over again. This would explain why the holes are approximately of the same size. The amount of antiseptic substance necessary to prevent further decomposition would be about the same in each area, and it would require the decomposition of a definite amount of wood to form this quantity. It may be objected that the holes are not always bounded by solid wood, but often run together. This would be explained by supposing the amount of humus formed at that point not sufficient to overcome the influence of the enzyme.

The conditions under which enzymes are active are

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* Marshall-Ward, H. On a lily disease. (Ann. Bot. 2 : 346. 1888.)
† Brown and Morris. Jour. of Chem. Soc. 57 : 505. June, 1890.
‡ Vignal. Cont. à l'étude des bactériacées. (Thèse. Paris.)

variable. Marshall-Ward * finds that in a distinctly alkaline liquid the mycelium of *Botrytis* will no longer grow. The enzymes of most bacteria are effective only in alkaline or neutral media † while those of many fungi are active in distinctly acid media although growth is more vigorous in neutral solutions.‡ Green § notes "the possible significance of the inhibitory effects of traces of acid or alkali in the solution in which the enzyme is working," and Smith ‖ has made similar observations. It is suggested that the humus compound may, because of its acidity, bring about conditions unfavorable to the activity of the enzyme formed in the cypress wood. As the humus compound is at first in liquid form, it saturates the wood cells for some distance around the hole, and thus completely fills the space where the mycelium is growing and many of the cells outside of this space. This explains why the hyphae as a rule grow out from the holes in straight lines without branching much in the wood surrounding the holes.

The enzymes are usually soluble in cold water, and can be precipitated from a solution by an excess of alcohol. Masses of diseased wood finely divided, as well as masses of mycelium, were digested with cold water for 27 hours; then to four parts of alcohol one part of the extract was added. A gray flocculent precipitate was obtained which on drying in a vacuum turned slightly darker. It was slightly soluble in water. Sections of *Taxodium* wood, young bean stems, etc., when placed in such a solution showed no perceptible change. As Hansen (l. c.) pointed

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* Marshall-Ward, H. On a lily disease. (Ann. Bot. **2** : 319. 1889.)

† Fermi, Claudio. Weitere Untersuchungen über die typischen Enzyme der Micro-organismen. (Cent. f. Bact. u. Parasitenkunde **10** : 404. 1891.)

‡ Hansen, A. Die Verflüssigung der Gelatine durch Schimmelpilze. (Flora n. s. **47** : 88. 1889.)

§ Green, J. R. On Vegetable ferments. (Ann. Bot. **7** : 83. 1893.)

‖ Smith, E. F. Sensitiveness of certain parasites to the acid juices of host plants. (Abstract in Bot. Gaz. **27** : 124. 1899.)

out, this method of separating enzymes is very unsatisfactory, as it weakens the enzyme and may even destroy it. In this case it is probable that much of the precipitate consisted of soluble humus compounds, and as these are likewise precipitated by alcohol a separation becomes difficult.

As the humus compound is insoluble in water (except a minute trace) it is difficult to add it to any culture media. It was dissolved in very weak KOH and added to agar and bouillon tubes which were inoculated with various bacteria and fungi. To a similar series of agar and bouillon tubes the KOH solution was added and likewise inoculated. In this double series no additional inhibitory effects due to the humus compound were evident.

The conclusions arrived at in this chapter indicate that the humus compound found in the wood surrounding the holes is formed because of the action of a fungus on the cell-walls of the wood, and that it is probably one of the products effective in preventing the unlimited spread and destructive action of the disintegrating powers of that fungus.

Age of the Fungus.

Taxodium distichum is an interesting tree in that it is one of the surviving members of a race of trees which were prominent in geologic times. Any disease which it is affected with may possibly have come down to the present day with its host. But few fungi are known in fossil condition. Unger * describes mycelia from the wood of a Tertiary tree; Williamson † figures a fungus, *Peronosporites antiquarius* from a stem of *Lepidodendron* (the same is also found in coal beds). Conwentz ‡ found a mycelium in fossil wood of *Rhizocupressinoxylon unira-*

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* Unger, F. Chloris protogaea. 1847.

† Williamson, W. C. On the organization of fossil plants of the coal measures. — Calamites. (Phil. Trans. R. S. L. **161**: 477. 1871.)

‡ Conwentz, H. Fossile Hölzer von Karlsdorf am Zobten 27. Danzig. 1880.

diatum. The mycelium had clamp connections and swellings like those of *Agaricus melleus*.

In accounts given of *Taxodium* logs found buried at various points * no mention is made of any defect. While in southern Louisiana last winter a number of sections of buried *Taxodium* logs were obtained.† These were found several miles back from the Mississippi river at an average depth of 10 ft. below Gulf level. Compared with other cypress logs found, these are not very old, but they are sufficiently far removed from the present time to deserve notice. In two of these logs unmistakable signs of peckiness were found. There was very little mycelium, but a sufficient number of hyphae with clamp connections were seen to justify the conclusion that they were the same as those growing to-day. The holes were few in number, but were not to be mistaken. It is probable that if other and older logs were examined more instances would be found. It would seem therefore that the disease is one which has extended back for some thousand years at least, and probably further.

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* Lyell, Sir Chas. Travels in N. A. in the years 1841–2. **1**: 114. — He says of cypress logs buried in the Dismal Swamp: "When thrown down they are covered by water, and never decompose except the sap."

Lyell, Sir Chas. A second visit to the U. S. 249. (1850). — (Cypress buried at the mouth of the Altamaha river.)

Carpenter, Wm. Account of the bituminization of wood in the human era, etc. (Am. Journ. of Sc. & Arts **36**: 118. 1839). — (Buried cypress forest at Port Hudson, La.)

Bartram, W. Travels through North & South Carolina, Georgia, E. & W. Florida 66. London. 1792.

† The logs were found at the following points: —

No. 1. Standing stump 9 ft. below surface, 7850 ft. back from river on Jourdan ave. *No. 2*. Horizontal log, butt 30 inches; center 10 ft. below surface, 8325 ft. from river on Jourdan ave. *Nos. 3 & 4*. Standing stumps same locality as No. 1. No. 3 had 260 rings in the heart wood. The surface where the samples were taken reads about 21 Cairo datum, mean Gulf level, 21.26 C. D., i. e. they were therefore about 10 ft. below Gulf level. See also Chart No. 76 of the Mississippi River Commission, for location of Jourdan ave.

If one considers the manner in which a fungus disease attacks plants at the present day, one will find that closely related plants are apt to be afflicted by the same disease. Thus *Plasmopara Cubensis* grows on a large number of genera of the *Cucurbitaceae*; *Gymnosporangium Nidus Avis* (*Aecidium*) on several genera of the *Pomeae* (*Rosaceae*); *Trametes Pini* on several genera of the *Coniferae*, and so on. Judging by analogy, one might expect genera nearly related to *Taxodium* to be diseased similarly to *Taxodium*. There are but a few genera, closely related to *Taxodium*, which grow at the present time. In North America: *Taxodium mucronatum* is found in Mexico; *Sequoia gigantea* and *S. sempervirens*, in California; *Libocedrus decurrens*, in California and Oregon; and the less closely related species of *Juniperus*. In addition to these there are a number of other species scattered over the globe, thus *Libocedrus Douiana* and *L. Bidwillii* in New Zealand, *Libocedrus cupressoides* and *L. Chilensis* in Chili, also a dwarf species in Iceland. A closely related tree, *Glyptostrobus Europaeus*, is found in some of the southeastern provinces of China. All of these trees were common over the whole earth in Tertiary times, and if a disease was common to them then, one might expect to find that to-day. Of the species enumerated, the *Sequoias* are apparently free from diseases of the wood * while *Libocedrus decurrens* and the species of *Juniperus* so far seen, are affected by diseases which cause local rotting of the wood much like that of the cypress. Of the other trees nothing is known so far. The fungus which causes the decay in *Libocedrus* is described in the following, while that found in the trunks of *Juniperus* species is to be described in a separate paper soon to appear.

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* Sargent, C. S. Silva of North America **10**: 140. 1896.

THE "PIN" DISEASE OF LIBOCEDRUS DECURRENS.

Historical.

In 1879 Harkness * published a note in which he called attention to a peculiar rot which occurs in the heart wood of the incense cedar, *Libocedrus decurrens*. Mayr † mentions what is evidently the same disease and describes it as follows: "A certain fungus, *Daedalea vorax*, appears to be very destructive, destroying the heart wood of standing trees; the fungus colors the wood red-brown and forms large lens-shaped cavities, at the same time the wood becomes very "brüchig." In 1896 the following appeared in Sargent's Silva: ‡ "The trunks of *Libocedrus decurrens* are frequently honey-combed and its value destroyed as a timber tree by *Daedalea vorax*, which destroys rounded masses of wood, disposed in long rows, sometimes extending through the length of the trunk, reducing them to a cinder-like powder." In the note published by Harkness one is led to believe that *Daedalea vorax* attacks *Abies Douglasii*, — not *Libocedrus*. *Daedalea vorax* is reported as growing on *Libocedrus decurrens* by Harkness.§ In a letter received from Dr. Harkness last year he says: "*Daedalea vorax* is a fungus which causes the rot in *Abies Douglasii*," etc. As to the *Libocedrus* disease he says: "Nothing could be found except mycelium which permeates through the diseased portion. No visible signs of any spores were seen. A careful search fails to reveal any of the fungus either among the roots or the surface of the tree, nothing indeed to indicate its presence until the tree has been felled." He says furthermore that the note

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* Harkness, H. W. A foe to the lumberman. (Pacific Rural Press. Jan. 25, 1879.)

† Mayr, Heinrich. Die Waldungen von Nordamerika 324. München. 1890.

‡ Sargent, C. S. Silva of North America **10**: 134. 1896.

§ Harkness & Moore. Cat. of Pacific Coast fungi 12. (Read before the Cal. Acad. of Sciences, Feb. 2, 1880).

in the catalogue of Pacific Coast fungi which records *Daedalea vorax* on *Libocedrus* (l. c.) is an error, and that instead of *Libocedrus* it ought to read *Abies Douglasii*. Mayr's statement is therefore the only one ascribing this disease of *Libocedrus* to *Daedalea vorax*, for the note in the Silva was based on the statements of Harkness and Mayr. In view of the fact that Mayr's report has never been confirmed I am inclined to the belief that *Daedalea vorax* has nothing to do with the decay of *Libocedrus*. This would leave the identity of the fungus which is responsible for this trouble as obscure as in the case of *Taxodium distichum*.

Character of the Disease.

Specimens of diseased wood received from various parts of California and Oregon have the appearance shown in Plate 2. The heartwood is full of lens-shaped cavities filled with a very brittle brown material. The latter is evidently the wood which formerly filled the cavity, but has been changed and has shrunken considerably. The cavities are placed irregularly in the wood with their longest diameter parallel to the wood cells. They vary considerably in size, from 1 inch long and $\frac{1}{4}$ inch wide to 10 inches long and $1\frac{1}{2}$ inches wide. In the majority of cases the separate cavities do not communicate with one another, but occasionally they do, as is evident from the cavities at the right side of the figure. The line of demarkation between sound wood and the brown decayed wood is a very sharp one. When the decayed wood is removed, the cavities have a sharply-defined, smooth bounding surface. In most respects the appearance of the wood is like that of diseased *Taxodium* wood.

Occurrence.

Concerning the prevalence and mode of occurrence of this disease, only such facts can be given as were learned from correspondents — particularly from Dr. Harkness,

Mr. A. J. Johnson, and a number of lumber companies in California, Oregon, and Washington. The disease is one which resembles the one in the cypress in its method of growth. The decay begins somewhere in the upper part of a tree and proceeds both up and down, the lens-shaped cavities appearing at first as darker areas in the wood. Older trees are very liable to be diseased. One correspondent, from southern Washington, says: "The proportion of trees affected is very large. We might almost say that the trees are generally so affected in this country." From Placer Co., Cal., another correspondent writes: "Probably more than one-half of the trees are affected in a greater or less degree." From intermediate points similar reports have been received. Young trees, i. e., such as are under 12 inches in diameter, are not apt to be seriously diseased. Climatic and soil conditions seem to have as little influence on the prevalence of the disease, as they do in the case of pecky cypress. Wherever *Libocedrus decurrens* grows, the defect is also to be found, i. e., from central California northward, as far as it has been possible to learn. The diseased wood is quite durable and can be used for fence posts, scantling, or for wood sills in buildings. The diseased wood is sold for $1–$3 less than sound cedar, per thousand ft. B. M., depending upon the degree of decay. This is an indication that it is at least capable of being used for some purposes. It might be mentioned here that boards cut from trees of *Juniperus Virginiana* affected with a similar disease were recently pulled off a barn where they had been 52 years. The Stimson Mill Co., of Ballard, Wash., writes: "We do not make any difference between sound and rotten cedar; $8 is the price for cedar delivered."

Name.

The only name which has been learned which is applied to this disease is "pin rot." The term "pecky" has

been applied to a form of decay in the cypress in which the wood is destroyed in local pockets. As this is a distinct form of wood destruction I would apply the term "pecky" to all forms of destruction where pockets or holes are formed as in the cypress. One would therefore call the affected *Libocedrus* wood "pecky cedar."

Structure of Diseased Wood.

The normal wood of *Libocedrus* differs but little from that of *Taxodium distichum*. Penhallow * places the two genera side by side. The diseased wood is decidedly different from the healthy wood. It has the appearance of a brown charcoal, breaks with a dull fracture and when pressed crumbles into a fine powder. In the mortar an impalpable dust is formed. In this respect it is very different from much-rotted cypress wood. In the latter the chemical transformation is far from uniform. Diseased *Libocedrus* wood is changed throughout; both the spring and the summer wood are changed, and very rapidly at that, i. e., there are no intervening steps as in *Taxodium*. A section made through the edge of a diseased pocket shows that at a certain point the cells are brown (Pl. 4, fig. 2). It will be noted that the color of fig. 2 is the normal color of the wood. Hand in hand with this coloration goes a shrinkage of the middle lamella, so that the walls of the tracheids become much thinner. They have lost all tenacity. If a piece of charred wood is boiled in water for a few moments it can be pressed into any shape like a piece of dough. Sections on a slide can be pushed about so that the cells assume a rhomboidal shape, i. e., the whole acts like a network of fine flexible wire. This is to some extent visible in Pl. 4, fig. 2, where a number of the walls are much bent, and do not have the rigid appearance of the healthy wood

* Penhallow, D. P. Generic characters of N. A. Taxaceae & Coniferae. (Trans. Roy. Soc. Canada ii. 2: 51. 1896.)

(fig. 1). The shrinkage of the wall causes breaks to appear in the pits (Pl. 5, fig. 11) and after a time in the walls (e). The shrinkage in a large mass of wood after a time becomes so great that the wood breaks at some point and gives rise to the appearance to be noted in the long hole at the left of the block in Plate 2. The three lamellae of the wood-cell are distinct even in greatly "charred" wood (Pl. 4, fig. 2).

The chemical nature of the wood cells has been entirely changed, and, as has been said, the change from sound wood to completely charred wood is immediate so far as microchemical tests can show. With dilute KOH the diseased wood swells to two or three times its size and the breaks in the walls close. A large per cent. is soluble in KOH and from such a solution humus compounds similar to those found in the cypress are obtained. Chlor-iodide of zinc turns the walls brown. When treated with dilute nitric acid the secondary lamellae gradually dissolve and there is left a skeleton framework composed of the primary lamella, the intercellular substance at the angle, and the fine membrane of the pits with the thickened torus. The solution takes place very gradually and can be followed very readily in a thin section. The nitric acid evidently dissolves out the substances into which the secondary lamella has been changed, leaving the more resistant primary lamella intact. From the HNO_3 solution a heavy flocculent orange mass is precipitated when excess of water is added. This precipitate is very soluble in alcohol and acetic acid, slightly so in ammonia, insoluble in ether, chloroform, benzine or acids. When dissolved in absolute alcohol, and cooled, no crystals form, but an oily substance settles on the walls of the dish as the alcohol evaporates. No further attempt was made to determine what this is. Nitric acid and potassium chlorate dissolve the entire wood substance. With H_2SO_4 the walls turn black and swell considerably. Phloroglucin and hydrochloric acid stain the rotted wood

carmine red verging toward orange, indicating the presence of coniferin. When treated for twelve hours with Javelle water and then stained with chlor-iodide of zinc the primary lamella turns light brown; with methylen blue it stains deep blue, indicating the presence of pectic substances.* The skeleton framework obtained after treatment with nitric acid stains blue with cellulose stains. This behavior towards various reagents shows that most of the cellulose has been removed and that the lignin substances have been transformed into substances readily soluble in nitric acid.

A number of chemical analyses were made of charred wood, following the method given by Allen † for determining the compounds found in wood. The wood was finely rasped and pulverized and dried at 100° C. After an aqueous extraction, the wood was extracted with alcohol and then with ether. 8.33% was found soluble in alcohol. The dried residue was hard, and broke with a bright fracture. It had all the attributes of a resin. Small quantities of pectic substances were found present, and a number of other products which were not determined. The rotted wood does not restore polarized light.

Wood Between the Holes.

The wood between the rotted areas is, as in *Taxodium*, perfectly sound as far as its structure is concerned. It reacts with reagents similarly to healthy wood. In the cells immediately surrounding the diseased spots, especially in the wood parenchyma and medullary rays, a red-brown substance is always present, which fills the cells as with plugs. It is very resistant toward acids and while boiling nitric acid dissolves the wood it does not affect this substance. Oxalic acid turns it black very quickly, also potassium bichromate and iron salts. These reactions

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* Mangin, A. Sur la présence des composés pectiques dans les végétaux. (Comptes rend. etc. **109**: 577. 1889.)

† Allen, A. A. Commercial organic analysis **1**: 323. 1898.

would place it with the tannins. Hartig found tannin in decayed wood, whereas it was not present in sound wood, and in the present case there seems to be a similar instance. What the origin of the tannin may be I do not venture to say.

Aside from the tannin a brown humus compound, similar to that found in *Taxodium*, occurs. It is found in the form of irregular granular masses which readily dissolve in dilute KOH. The medullary rays in particular are filled with this substance (Pl. 4, fig. 2); it seems to permeate the cell-walls, for these turn the characteristic yellowish-brown color on addition of KOH, and the tracheids become filled with the brown liquid. Extractions of the surrounding wood with KOH yield considerable quantities of the compound. Nowhere were any dried plates found, such as were described for the cypress.

Mycelium and Spores.

The mycelium found in the diseased *Libocedrus* wood agrees so closely in appearance with that found in the *Taxodium* that the drawing on Pl. 5, fig. 1 may represent it as well. Few hyphae are to be found in the charred wood or the wood about the holes. Abundant evidence of their having been present is seen in the numerous holes which puncture the walls of the charred wood in all directions (Pl. 4, fig. 2). No preference is shown for the pits. The hyphae are most abundant in wood away from the rotted holes. They are colorless, branch frequently and are provided with a large number of clamp connections. The finest threads pass through the walls in all directions. Between the rotted areas the hyphae usually extend directly from hole to hole, just as in the *Taxodium*. In places the mycelium collects in large masses or felts; in these felts the hyphae are matted. Many crystals of calcium oxalate give the whole a white appearance.

A brown mycelium like that found in the cypress was

found in a number of cases. How common this is cannot be said, as the number of specimens examined was from but a small number of trees. The threads have marked attachment organs (Pl. 5, fig. 9 "d–f") which have been described under the cypress disease.

In the rotted wood, and particularly around the same, the cells are often filled with great masses of spores like those seen in isolated cases in the cypress (Pl. 5, fig. 2). These spores are present in such numbers, that they often completely fill the tracheids. Several spores were found with very fine hyphae attached (fig. 5) and many showed small knobs at one end. It will be necessary to see a large number of trees to determine where these spores came from.

Localization.

The localization of the diseased areas is quite as marked in *Libocedrus* as it is in *Taxodium*. One may have a block of wood 3×3×1 in. which looks perfectly sound, but when split longitudinally it may contain a sharply defined lenticular hole. It is suggested that probably similar reasons to those given for the cypress hold here. The investigation with respect to this point is to be regarded as but begun. When it becomes possible to grow the fungus found in the holes one may expect to reach more decisive conclusions.

SUMMARY.

In the foregoing, two forms of decay have been described, one destroying wood of *Taxodium distichum*, the other of *Libocedrus decurrens*. In both cases the wood is destroyed in localized areas, which are surrounded by apparently sound wood. The cell-walls are changed into compounds which diffuse through the walls and fill the cells surrounding the decayed center; and these have been called humus compounds. In both, a fungus mycelium occurs with strongly marked characteristics, which flourishes

within the diseased centers and grows between these centers without affecting the intervening wood. This wood can be utilized for many purposes even when much rotted, and in neither case does the mycelium grow after the tree has once been cut down. The two trees thus diseased, both representatives of a race of trees the majority of which are extinct, are closely related genetically, although growing in different parts of the country. The two forms of decay differ but slightly, and not more than might be expected in two woods of different character. Taking those facts into consideration, it appears probable that the two diseases are caused by one and the same fungus, the fruiting form of which has not yet been found.

EXPLANATION OF PLATES ILLUSTRATING DISEASES OF TAXODIUM AND LIBOCEDRUS.

Plates 1, 2, plate 4, fig. 3, and the coloring of plate 3, fig. 2, and plate 4, fig. 2, were prepared under my direction by Miss Harriet P. Learned.

Plate 1. — 1, Branch of *Taxodium distichum*, showing early stage of the pecky disease. The wood turns yellow in longitudinal lines ($\times\frac{5}{6}$). 2, A block of *Taxodium distichum* cut from the heart of a tree several hundred years old, showing advanced stage of peckiness. In a large number of trees the rotted portion is more yellow than that shown in the figure ($\times 1$).

Plate 2. — A block of *Libocedrus decurrens* showing advanced stage of the pecky disease. The rotted wood has fallen out from the holes at the right of the figure leaving a smooth surface ($\times\frac{1}{2}$).

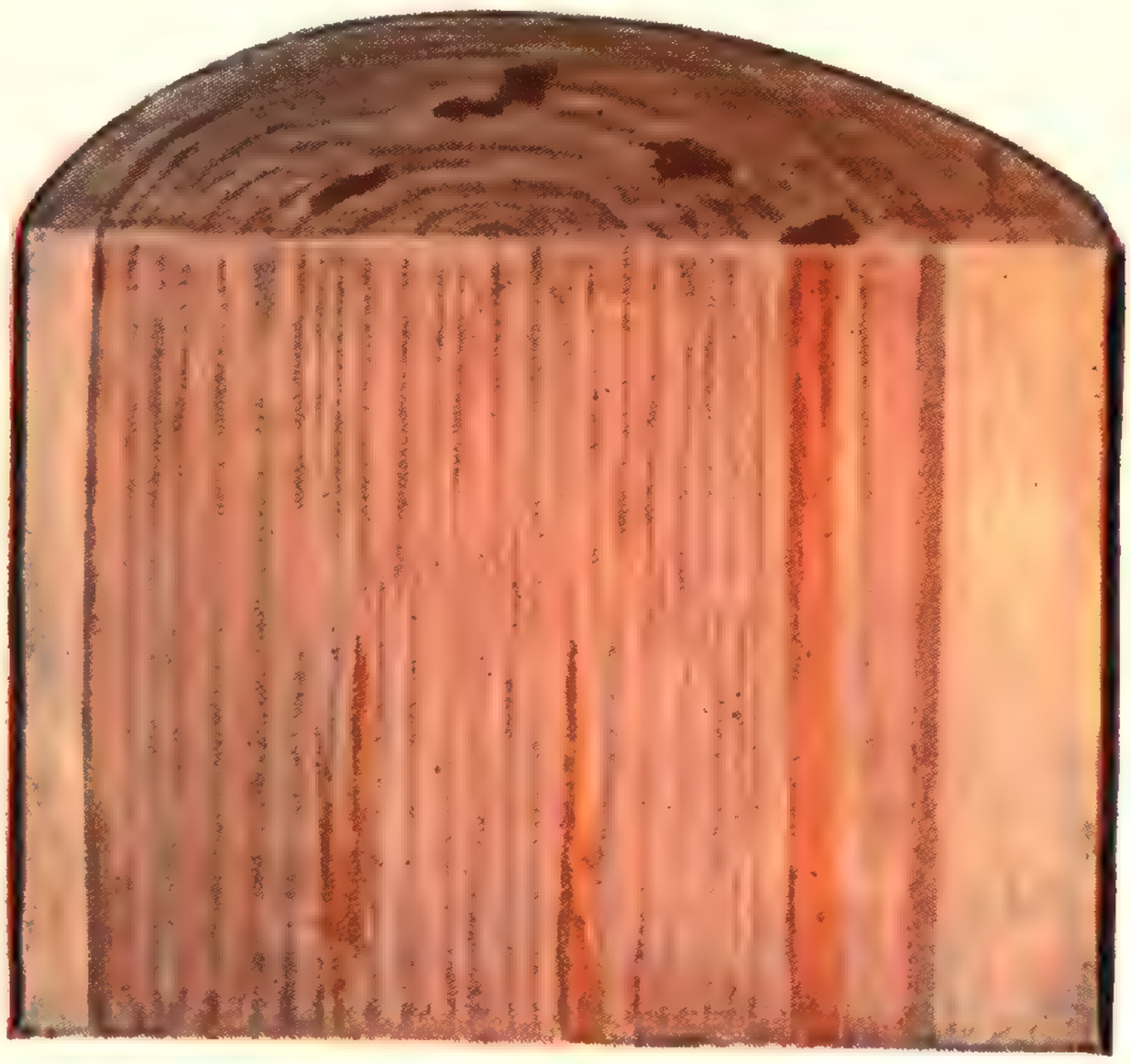
Plate 3. — 1, Transection of pecky cypress wood. The section was made so as to include some of the much rotted wood, seen at the bottom of the figure, also some of the sound wood. It was stained with phloroglucin and HCl. The violet of the original section was somewhat more marked than is the color in the figure. The portions staining violet indicate wood which has not been affected by the fungus, those staining yellow show where the coniferin elements have been extracted: 'm' medullary rays; 'k' cell-walls from which the coniferin has been extracted; 'p' normal cell-wall; 'd' primary lamella resisting the disintegrating factor longer than the secondary lamellae; 'h' perforation of cell-wall made by fungus hypha (magnification same as fig. 2). 2, Tran-

section of pecky cypress wood, showing the transition from sound wood to humus compound, after staining with phloroglucin and HCl.: 'g' primary lamella, unaffected; 'p' small masses of humus compound resulting apparently from the transformation of the tertiary lamella; 'i' wood staining yellow, an intermediate stage between the sound wood and the humus compound; 'h' a thicker layer of humus compound than the one indicated at 'p'; 'c' a still more advanced stage in the humus formation; 'e' the entire cell-wall has been transformed into the humus compound; 'u' piece of cell-wall not yet changed to humus compound.

Plate 4. — 1, Transection of sound wood of *Libocedrus decurrens*, showing spring and summer wood: 'h' brown hypha with attachment organs; 's' spores often found in the wood cells. 2, Transection of diseased wood of *Libocedrus decurrens*, i. e. wood from one of the pockets. The color is the natural color of the wood. The medullary ray is filled with brown humus solution. 3, Block of *Taxodium distichum* showing pecky hole lined with white fibers, consisting of pure cellulose (×½). 4, Two tracheids from wood surrounding a diseased spot in *Taxodium distichum*. The tracheids are filled with brown humus compound which has cracked in drying.

Plate 5. — 1, Mycelium from decayed wood of *Taxodium distichum*, showing the numerous clamp connections. 2, Spores from pecky wood of *Libocedrus decurrens*. (The line at the top is 10 μ.) 3, Portion of a tracheid near diseased area of *Taxodium distichum*. The pits appear corroded because of a peculiar arrangement of resin globules. (Magnification same as fig. 2.) 4, Brown chlamydospores from rotted wood of *Taxodium distichum*. 5, Brown spores from wood of *Taxodium distichum*. These are like the ones found in the red cedar. 6, Spores from wood of *Quercus alba* destroyed by *Polyporus sulphureus* (from Williamsville, Mo.; magnification same as fig 5). 7, Spores from wood of *Taxodium distichum*, resembling Willkomm's *Xenodochus ligniperda*. 8, Minute bodies, which appear in the humus compound when the latter is slowly dissolved away. Two views are represented (magnification same as fig. 2). 9, Mycelium showing attachment organs: 'a–c' from wood of *Taxodium distichum*; 'd–f' from wood of *Libocedrus decurrens*. 10, Longisection of pecky cypress wood, showing gradual disintegration of the tracheids: 'a' normal tracheid filled with humus compound; 'b' similar tracheid with colorless mycelium; 'c' tracheid with pits looking as if corroded; 'd' tracheids with walls which are beginning to contract; 'e' tracheid in which the walls show spiral cracks; 'f' and 'g' tracheids showing final stages in the process of solution. (Magnification same as fig. 1.) 11, Longitudinal section through pecky wood of *Libocedrus decurrens*: 'a' normal tracheid; 'b' tracheid showing beginning of disintegration, the pits show cracks, some spores are collected near a wall; 'c' and 'd' tracheids which have contracted considerably, showing cracks in the pits and the wall. (Magnification the same as the preceding figure.)

Plate 6. — Upper figure a pile of pecky cypress boards at Lutcher, La. The boards have been exposed some time, so that the rotted wood has been washed from the holes. The lower figure is a photograph of the vertical banks of a ditch on Dauphin St., Mobile, Ala. (in front of the house of Dr. Chas. Mohr). The bank is lined with pecky cypress boards, which are held in place by horizontal braces.



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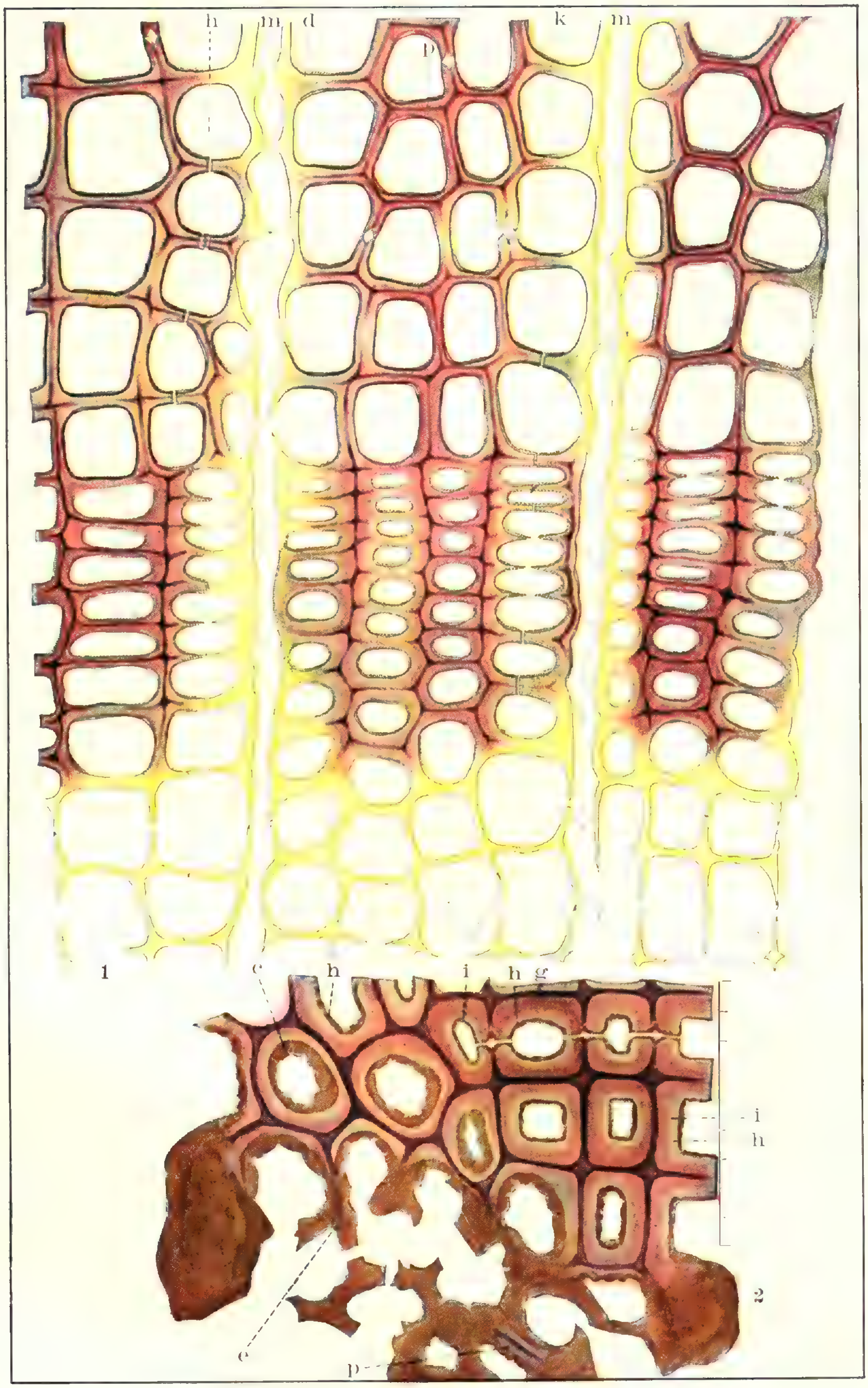
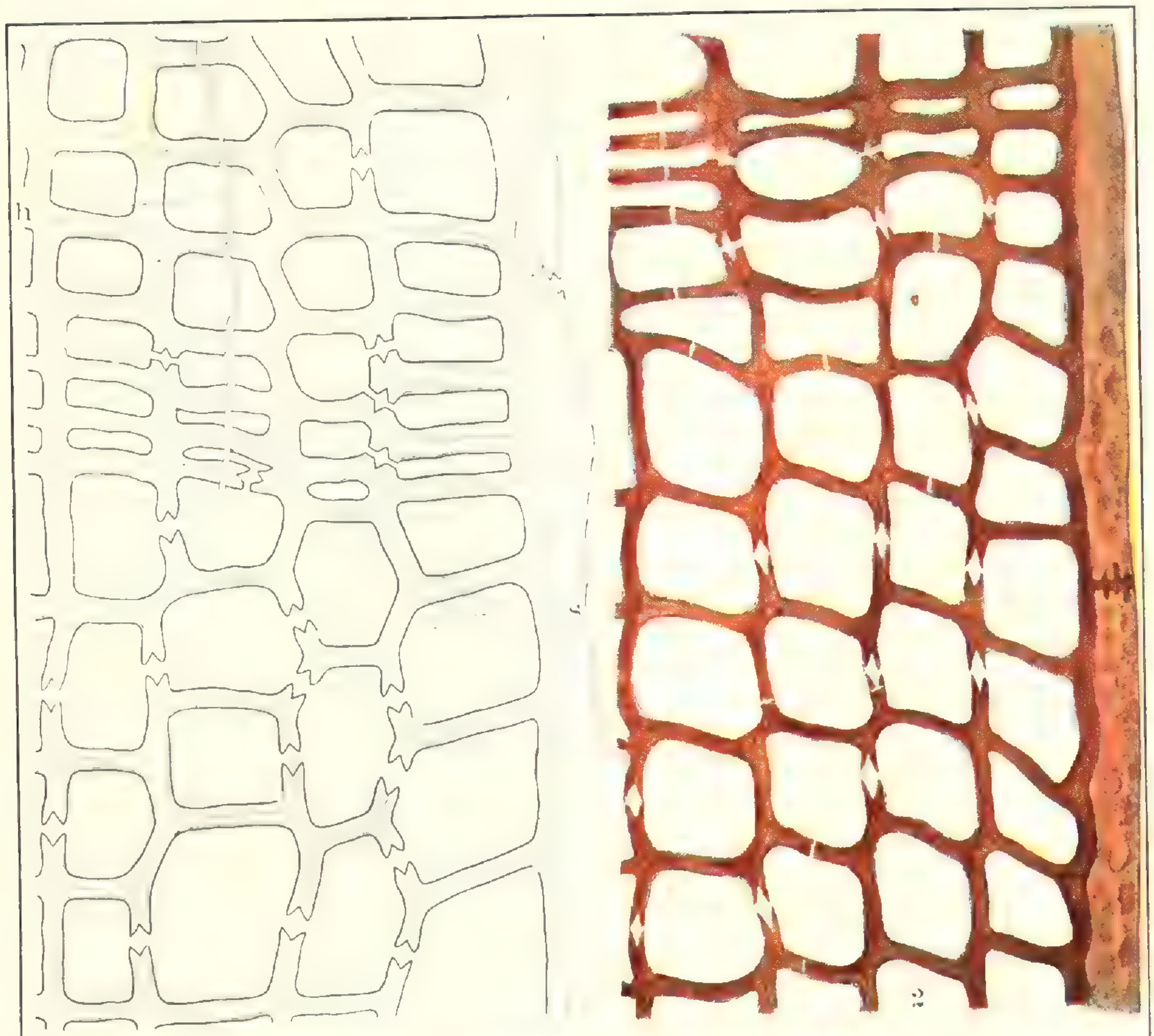
PECKY CYPRESS.

PECKY INCENSE CEDAR.



PECKY CYPRESS.



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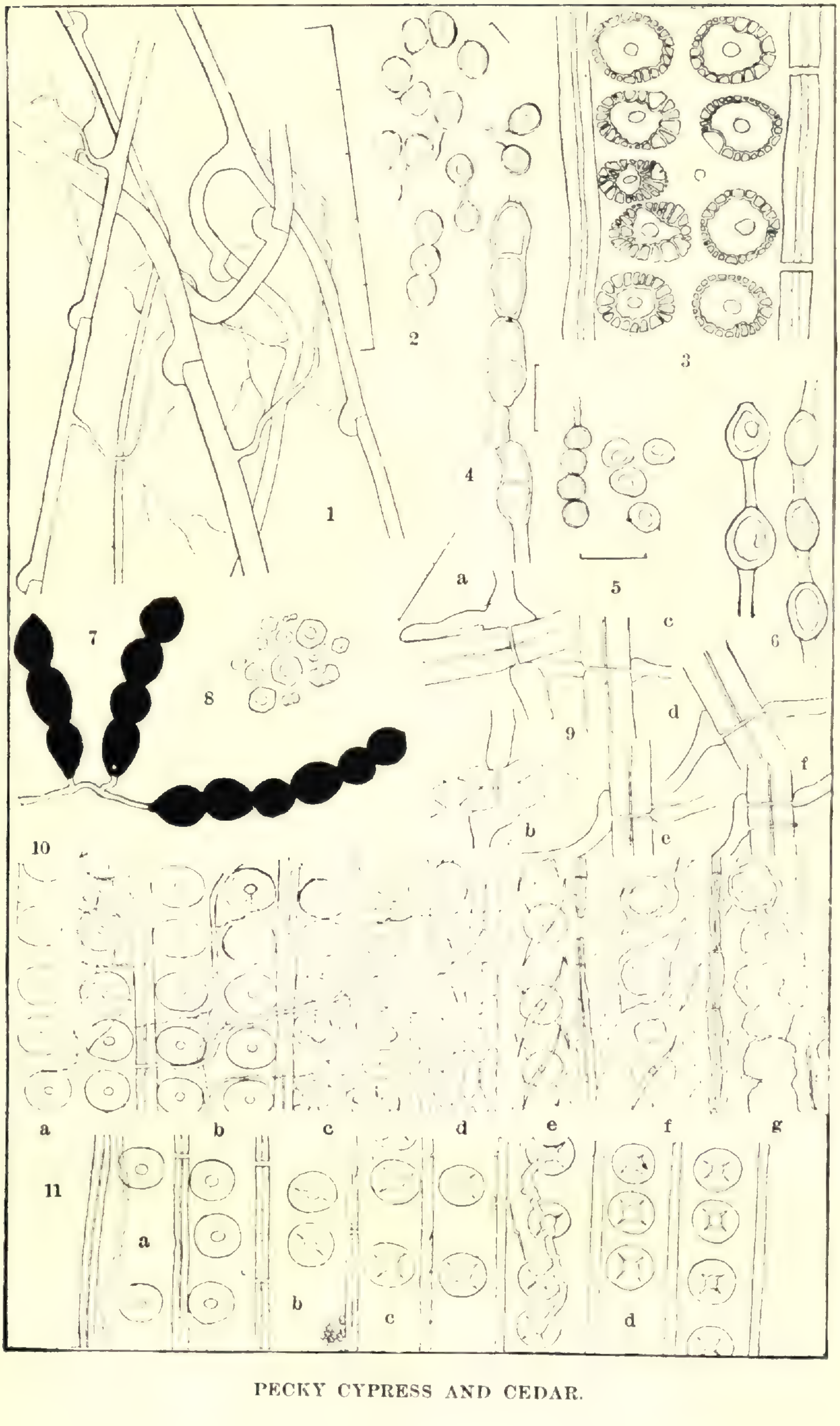
PECKY CYPRESS AND CEDAR.



PECKY CYPRESS AND CEDAR.

PECKY CYPRESS.

AGAVE EXPATRIATA AND OTHER AGAVES FLOWERING IN THE WASHINGTON BOTANIC GARDEN IN 1898.*

BY J. N. ROSE.

In the ninth Annual Report † I described the five species which flowered in the Botanical Garden at Washington in 1897. During the year 1898 six species flowered, one of which, however, was *A. Washingtonensis*, the same individual that flowered in 1897, while another was a second specimen of *A. attenuata*. Since both of these show some peculiarities they are here discussed at some length. Another species which I call tentatively *A. heteracantha*, but which will doubtless prove distinct, is described briefly with the hope that it may lead to a clearing up of the confusion which surrounds the *heteracantha* group. A fourth species proves to be undescribed. As in the case of *A. Washingtonensis*, nothing is known of its previous history except that it has long been in cultivation here. Two species of the herbaceous type, *A. Virginica* and *A. maculosa*, have also flowered. Of the latter species seven specimens have flowered for us and these show much variation. These two species, which are believed to belong to a different generic type, will not be discussed in this place, as I propose to treat them elsewhere at an early day.

AGAVE ATTENUATA.

A specimen of *Agave attenuata* began to send up its spike about November 1, 1898. On November 5, the spike measured 2 feet,4 inches; November 10, 3 feet, 4

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* Published with the approval of the Secretary of the Smithsonian Institution.

† Rept. Mo. Bot. Gard. 9: 121–6. *pl. 29–31*.

Separates issued June 3, 1899.

inches; November 16, 4 feet, 4 inches; November 19, 5 feet; November 28, 5 feet, 6 inches, and finally it reached 6 feet (?). It began to flower on December 9, and continued until in January, 1899. This specimen differs considerably from the one which flowered in 1897,* especially in its curved spike, in the fewer bracts on the lower part of the peduncle, and in having the flowers borne in clusters of 6 to 8, while in the other plant the spike was very stiff and erect, the bracts very numerous at the base of the peduncle, and the flowers in twos. In most aspects the plant which flowered in 1898 corresponds nearly with those specimens which have flowered in Europe, although none have been described as having so many flowers in a cluster. Our specimen may be described as follows: —

Stem 4 feet high; leaves about 20, 2½ to 3 feet long, 6 to 8 inches broad; lower bracts leaf-like, scattered, not scarious, ovate, acuminate below, acute above, spike green; flowers in clusters of 6 to 8; ovary green, 8 to 9 lines long; perianth 12 to 14 lines long, the tube very short (2 lines long), the segments oblong, as the stamens protrude becoming recurved and as they wither becoming erect again, at first whitish-green, later becoming yellowish-green; stamens inserted at the top of the short tube, 2½ inches long, anthers 10 lines long, pale yellow; style 3 inches long. — Plate 7.

AGAVE HETERACANTHA?

A plant which I have called *Agave heteracantha* for the present began to flower July 16, and continued until August 7. It is not known from what source our plant came but it is probably from Northern Mexico. I have referred it to *A. heteracantha* simply because there seems to be no other place for it. The species *heteracantha*, as now treated is certainly an aggregate of several species, but it will really require considerable field work to clearly define the limits of these various forms. *Agave Lechuguilla*, one of these forms, seems, however, to be clearly distinct, being characterized especially by its very long terminal spine.

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* Rept. Mo. Bot. Gard. 9 : 124. *pl. 31*.

My specimens from the Garden may be described as follows: —

Leaves about 25, dark green, not banded down the center but with a few short, dark lines down the back, 12 inches long, 1 inch or less wide, the margin continuous, end spine ½ inch long; peduncle and inflorescence 8 feet high, pale and glaucous; bracts slender and scarious; ovary glaucous, 6 to 7 lines long; filaments and style reddish, twice as long as the short segments of the perianth, the latter 5 to 6 lines long.

Specimens are in the National Herbarium prepared by J. N. Rose, August, 1898 (No. 4073).

Agave Washingtonensis.

After this Agave flowered in the spring of 1897 the plant was put out in the grounds of the gardens with other species where it remained until late in the fall, when it was removed to one of the greenhouses, though supposed by the gardeners to be dead. During the summer a single plantlet developed on the flowering spike and about a half dozen capsules matured seed. This seed has been distributed to several of the leading Botanical Gardens and about 50 seedlings are now growing in the propagating house here.

This species has shown no signs of developing stolons. After the old plant had been installed for the winter no attention was given to it. Some time in March, Mr. Oliver, the Assistant Gardener, called my attention to the appearance of several buds in the axils of the old leaves. When I examined the plant I discovered 7 shoots or branches, the two longer being 20 and 30 inches long respectively. About the first of May these two latter branches (now 3 feet and 4 feet long respectively) began to flower and later set seed; two of the other shoots had developed into short spikes but were only in bud, while some 4 or 5 other shoots were seen in the axils, several producing flowers when only 2 or 3 inches long. No new leaves have developed on the plant since it began to flower in February (?), 1897.

In August I again visited the plant and found that a new shoot had developed into a spike some 3 feet long and was then covered with flowers. This spike matured fruit in December. In November the old plant began to send out of the axils of the old leaves a number of small plantlets instead of flowering spikes. The old plant still shows considerable vitality although no new leaves have been developed since it first began to flower in February, 1897, and we are looking with interest to see what new phase it may assume before it dies.

As originally described the flowers are in clusters of 3 to 6; the buds are oblong, slightly tinged with brown; the perianth lobes are oblong, 7 lines long, spreading above, slightly tinged with brown, tipped with a small tuft of hairs; tube very short; the filaments (15 lines long) and the anthers before dehiscing are reddish-brown; the style is also reddish, at first much shorter than the filaments, finally overtopping them. The flowers produce an abundance of nectar. — Plate 8.

AGAVE EXPATRIATA Rose sp. nov.

In the spring and summer of 1898 an Agave labeled *A. Brauniana* flowered for us. The leaf characters showed at once that it was not of the group to which that species belongs, but that it very clearly belonged to Mr. Baker's group *Marginatae*, of which *heteracantha* and *xylonacantha* are examples. It proves to be quite unlike any of these species, and although I have gone over the related species again and again I see no other course open but to describe it as new. This was not done until the species had been looked up both at Kew and at the Missouri Botanical Garden and I was informed by both Mr. Baker and Dr. Trelease that the species was not in their collections.

The flowering spike was first noticed on March 14, 1898, the first flowers opened May 9, and the last on June 24. The spike on March 17, measured 4 feet, 3 inches; on March 20, 6 feet (including the one-foot peduncle); on March 25, 7½ feet; on April 7, 10 feet (including the 5-foot peduncle); on April 21, 12 feet, 8 inches, and

finally on June 2, after about three-fourths of the spike had flowered, it measured 14 feet.

This species has long been grown in the Botanical Garden at Washington, but its previous history has been lost. It belongs to the group *Marginatae*, but is not very near any of the described species. It may be described as follows: —

Very shortly caulescent; leaves about 40, 2 to 2½ feet long, 3½ inches wide near the middle, narrowed slightly toward the base, 2½ inches broad just above the base, thin except toward the base, here 1 to 1½ inches thick, light green, not at all banded; margin with a narrow but continuous horny border; teeth more or less curved; end spine an inch long; uppermost leaves about 10, erect, standing close against the spike, linear, somewhat abruptly passing into the scarious entire bracts of the peduncle; bracts glaucous, broad at base (1½ to 2 inches broad) but soon contracted into a long acumination, the lower ones a foot long, becoming shorter above, all at first appressed to the peduncle, but before the flowers open much spreading; flowers usually in twos, rarely single or in threes; perianth about 7 lines long; tube very short; segments pale green or cream-colored, glabrous except a tuft of hairs at tip; stamens 1¼ inches long; anthers orange-color, or, in the upper flowers, pale yellow, even in the bud. — Plates 9, 10.

EXPLANATION OF PLATES OF AGAVE.

Plate 7. *Agave attenuata*, — habit, reduced.

Plate 8. *Agave Washingtonensis*, — lateral flowering, reduced.

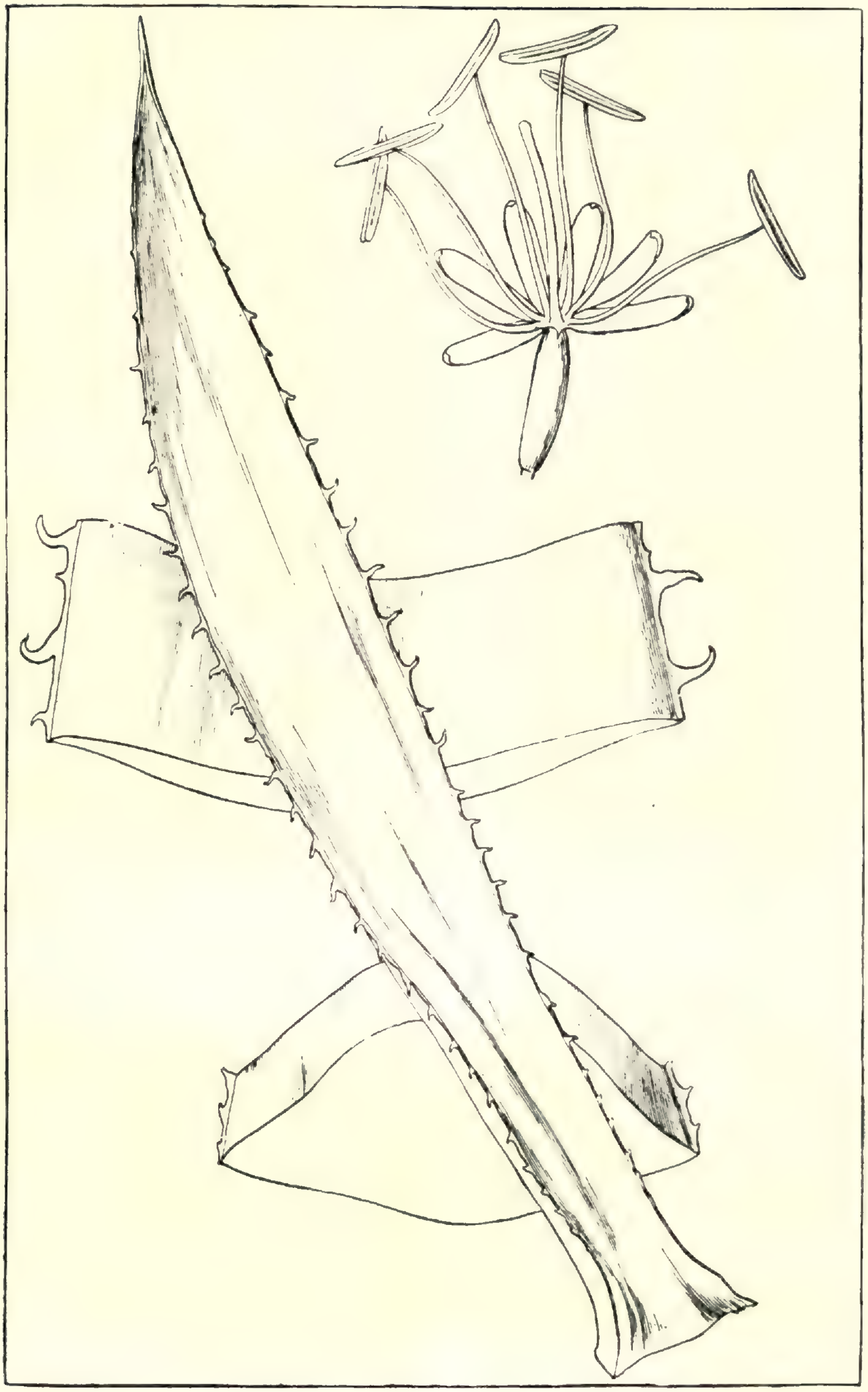
Plate 9. *Agave expatriata*, — habit, reduced.

Plate 10. *Agave expatriata*, — leaf, × ¼, with sections, natural size; flower, natural size.

AGAVE ATTENUATA.

AGAVE WASHINGTONENSIS.

AGAVE EXPATRIATA.



AGAVE EXPATRIATA.

A REVISION OF THE AMERICAN SPECIES OF EUPHORBIA OF THE SECTION TITHYMALUS OCCURRING NORTH OF MEXICO.

BY J. B. S. NORTON.

Since Boissier's monograph of the genus Euphorbia was published in De Candolle's Prodomus, in 1862, no general work on the North American species of the above section has appeared, though a number of new species have been distinguished, and most of them published in isolated works. Before the time of Boissier's monograph, Dr. George Engelmann had done a large amount of work on the genus in North America, and published several papers, and had at that time a monograph in preparation. Many notes and specimens sent by Engelmann were used by Boissier in his work. Afterward Dr. Engelmann continued his studies in Euphorbia until his death, being the only American botanist well acquainted with this group of plants. His synopsis of the Euphorbias of the Mexican boundary gives a complete account of the species in the Southwest. In later years Dr. C. F. Millspaugh has done considerable work upon the genus in this country; but aside from the works of Engelmann and Boissier, very little has been published upon the section under consideration.

Some two and a half years ago this revision was begun at the Missouri Botanical Garden, and has been carried on there with the aid of the Garden herbarium and library, which contain the rich and invaluable herbarium, library, and notes of Dr. Engelmann. Besides these I have used the material of this section from the herbaria of Harvard University, Columbia University, the United States National Museum, the California Academy of Science, Dr. C. F. Millspaugh, the Kansas State Agricultural College,

Separates issued July 10, 1899.

Vermont State University, Ohio University, Iowa Agricultural College, and Florida Agricultural College; and while in Philadelphia for a few hours in 1898, I made a hasty examination of the herbarium of the Philadelphia Academy of Sciences. My thanks are due to those who have kindly permitted me to examine the collections in their charge and to many others who have sent smaller collections or specimens from various parts of the country; and especially to Dr. Wm. Trelease, at whose suggestion the work was taken up, for every possible facility and kindness in carrying on the work at the Garden and securing for my examination the collections from the larger herbaria of the country.

Aside from recording what has come to light in a study of the material accumulated in herbaria from the many collections of the thirty-seven years since the last revision, it is hoped that the present monograph may at least have some value in collecting the isolated descriptions, and putting in more accessible form our knowledge regarding this group of plants; and that it may be some aid to future students of Euphorbia.

In general I have followed the system of classification used by Boissier, and, with little modification, by the principal systematists since his time. The subsections are left practically as he defines them, with the exception of *Ipecacuanhae* which is modified by the removal of *E. Ipecacuanha* L., its relative *E. gracilis* Ell. and *E. trichotoma* HBK. The first two must be excluded from *Tithymalus* because of the presence of distinct though minute stipules, and very narrow but usually evident glandular appendages. *E. trichotoma* is placed in the subsection *Esulae* because of the carunculate seeds. Some slight rearrangement of the species in the subsections has been made, which I believe will better indicate the natural relationships.

The section *Tithymalus* comprises the greater part of the known species of Euphorbia, containing nearly 400 of the 700 or more described. Comparatively few occur in

America, where the sections *Anisophyllum* and *Adenopetalum* predominate. The greater number of our species are in the southwestern part of the country and are largely xerophytic in habitat. Of the species here included eight are introduced from Europe.

The plants have one to many herbaceous or occasionally suffruticose stems from annual, biennial, or perennial roots or sometimes rootstocks. They usually branch at the crown and in the axils of the scattered stem leaves (decussate in one species). The main stem is terminated by an involucre which is usually abortive or with the pistillate flower abortive. This is surrounded by three to many branches of the cymose umbel (rays). In the descriptions the length of these is given to the first floral leaves. The rays are subtended by leaves usually somewhat different in form from those of the stem (umbel leaves). The rays branch dichotomously an indefinite number of times, the involucres being terminal in the forks, and they and the leaves becoming smaller and more imperfect toward the top. The leaves in the umbel (floral leaves) are opposite except in *E. trichotoma*, and wider in proportion to the length than those below, and tend to be bilaterally unequal. The involucres are usually turbinate or campanulate, and are composed of five modified leaves joined, with the upper ends (lobes) free. Between the lobes are the five or less nectariferous glands. In most cases one of the glands is absent or replaced by a sixth lobe, leaving a sinus in which the pedicel of the pistillate flower is declined. The glands and lobes next this sinus are often different in size and shape from the others. The lower involucres are longer peduncled and often have five or more glands when those above have normally four. In the center of the involucre is the single pistillate flower. The three styles are free or united below and more or less bifid above, and erect or spreading at different periods of their life history. They are terminated by the clavate or often almost capitate

stigmas. Opposite each lobe is a group of staminate flowers, indefinite in number and subtended by minute bracts which partake more or less of the characters of the lobes. The pendulous seeds are smooth or variously sculptured. The embryo is pendent and the cotyledons are ovate and often cordate. The measurements of seeds are exclusive of the caruncle. The caruncle, which is usually present, occupies an oblique ovate or triangular space about the funiculus. The raphe forms a line from this to the chalaza at the lower end where there is often a circular depression.

The small size of the flowers and the complicated structure of the inflorescence make the study of the genus somewhat difficult; and the great variability of the leaf and involucral characters has led some authors into error. The method of branching and the phyllotaxy offer much aid in classification, as also does the shape of the glands and lobes within certain limits. The seeds give the best specific characters, being very constant in shape and markings and usually in size, except in the perennial species of the subsection *Esulae*, where the seeds of several species differ but little.

A list of the specimens seen is given at the end of each description. Other important localities mentioned by other authors are given at the end of this.

I have intended to cite all the synonyms of species described, the most important American publications, and some of the better illustrations of such as have been figured. For the most part, the Madison rules for citation have been followed. The illustrations are cited after the other works, and preceded by a dash. Some of the more important general works are indicated at the end of the revision; for other literature the reader is referred to these, especially to the first three, where more complete bibliographies are given.

In the diagram of relationships, Table A, the length of

lines shows in some degree the probable distance of relationship; and as nearly as possible apparently related species of different groups have been approximated.

For morphological works see Warming, Er Koppen hos Vortemaelken en Blomst eller en Blomsterstand? Köbenhavn. 1871; and Eichler, A. W. Blüthendiagramme **2**: 386–392. 1878.

For anatomical works see Pax, F. Die Anatomie der Euphorbiaceen in ihrer Beziehung zum System derselben. Engler's Bot. Jahrb. **5**: 384–421. *pl. 6, 7.* 1884; and Pammel, L. H. On the Seed-coats of the Genus Euphorbia. Trans. Acad. Sci. St. Louis **5**: 343–368. *pl. 12–14.* 1891.

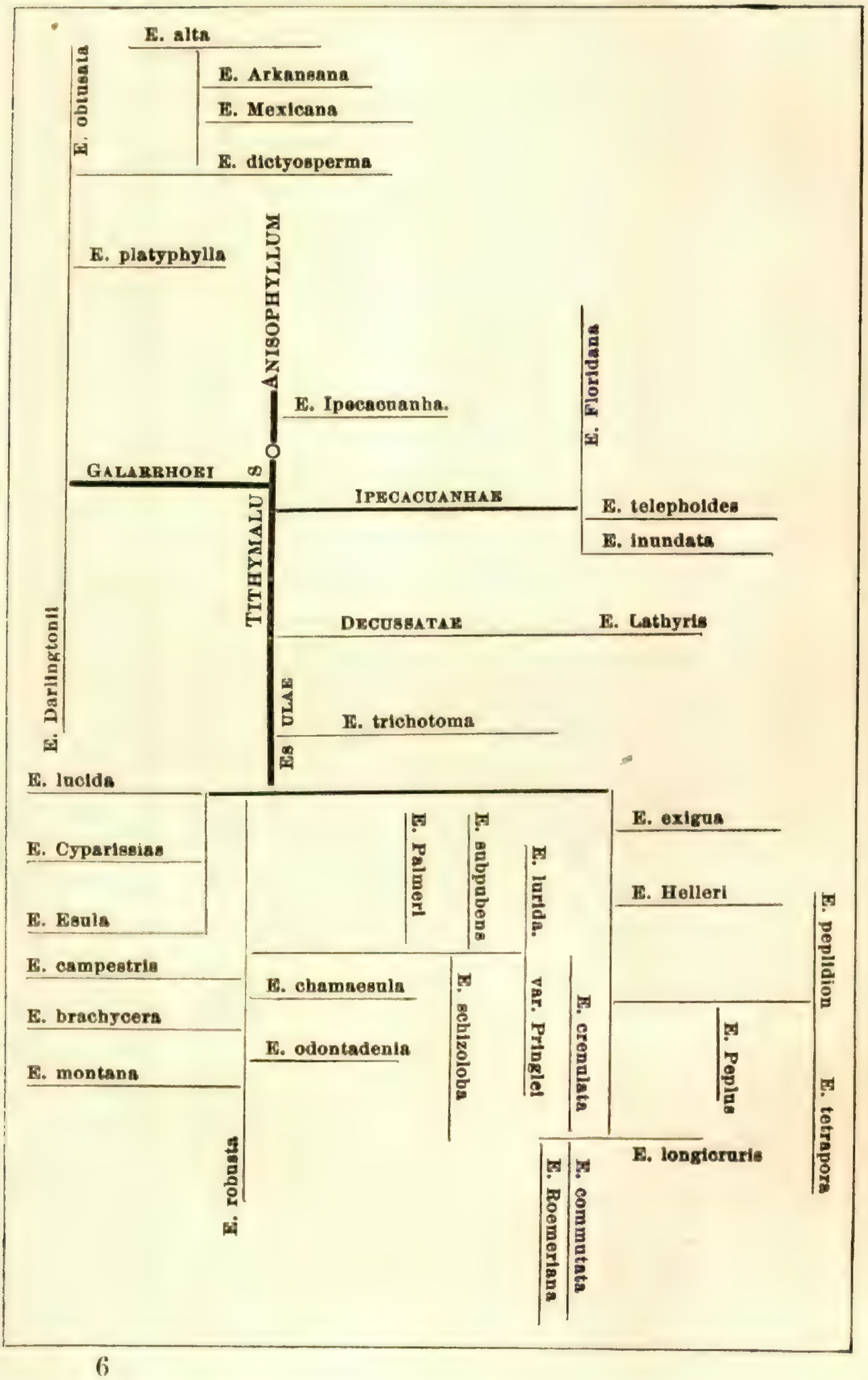
For works on distribution, etc., see Bentham, G. Notes on Euphorbiaceae. Journ. Linn. Soc. Bot. **17**: 185–267. 1880; and Kränzlin, Die Verbreitung der Arten der Gattung Euphorbia. Progr. 39. Berlinisches Gymnasium zum grauen Kloster. 1876.

For works on medicinal and economic properties see Dragendorf, G. Die Heilpflanzen 385–391. 1898; and Millspaugh, C. F. Medicinal Plants **2**: 147–150. 1892.

EUPHORBIA Linn. Sp. Plant. 450. 1753.

§ TITHYMALUS. The floral leaves opposite, the others usually alternate, exstipulate; inflorescence cymose umbellate; glands exappendiculate.

TABLE A.— DIAGRAM OF RELATIONSHIP.



ANALYTICAL KEY.

I. Glands of the involucre with a rotund and entire margin.

A. Leaves entire, seeds without a caruncle. *E. telephoides, E. inundata.*

B. Leaves serrulate, seeds carunculate.

a. Ovary and capsule smooth.

1. Seeds ovoid, pointed at apex, rays 5. *E. Helioscopia.*

2. Seeds globose lenticular, rays 3. *E. leiococca.*

b. Ovary and capsule verrucose.

1. Seeds smooth, rays 5 or more; perennial by a rootstock. *E. Darlingtonii.*

2. Seeds smooth (sometimes faintly reticulate in *E. obtusata*), rays 3 to 5; annual.

Pubescent, leaves acute, rays 3 to 5. *E. platyphylla.*

Smooth, leaves obtuse, rays 3. *E. obtusata.*

3. Seeds reticulate, rays 3; annual or some biennial or perennial by crown buds.

* Stems cymosely branched below the umbel, capsules short warted.

† Styles divided nearly to the base, leaves rotund or retuse at the apex. *E. dictyosperma.*

†† Styles not divided below the middle, leaves acute or only obtuse.

Most of the floral leaves longer than wide. *E. Arkansana Missouriensis.*

Floral leaves about as broad as long. *E. Arkansana.*

Many stemmed, floral leaves narrowly oblong. *E. Mexicana.*

** Racemosely branched, capsules long warted; high mountain plants. *E. alta.*

II. Margins of glands not rotund nor entire.

A. Stem leaves decussate. *E. Lathyris.*

B. Stem leaves alternate.

a. Most of the floral leaves alternate; trichotomously branched. *E. trichotoma.*

b. Floral leaves opposite, rays dichotomous.

1. Seeds not carunculate, involucres shorter than their peduncles, calyx 3-lobed.

* Peduncles 5 to 12 mm. long, floral leaves cordate, glands wrinkled. *E. Floridana.*

** Peduncles 1 to 3 cm. long, floral leaves rarely cordate, glands smooth.

Leaves of the stem lance-linear. *E. inundata.*

Leaves of stem oblanceolate to obovate. *E. telephoides.*

2. Seeds carunculate, calyx obscure, discoid or triangular, involucres usually longer than their peduncles.

* Seeds smooth. (See also *E. chamaesula* and related species when immature).

† Rays 3; annual. *E. Helleri.*

†† Many rayed; perennial.

Capsules verrucose, leaves linear; not over a foot high. *E. Cyparissias.*

Capsules slightly roughened or smooth, leaves lanceolate; over a foot high.

Stem leaves less than 1.5 cm. wide. *E. Esula.*

Stem leaves over 1.5 cm. wide. *E. lucida.*

** Seeds tuberculate; low annual with acute floral leaves. *E. exigua.*

*** Seeds with rows of pits, at least on the ventral side; annuals, usually with obtuse floral leaves.

† Capsule crested. *E. Peplus.*

†† Capsule smooth, or nearly so.

Two sulci on the inner face of the seed. *E. peplidion.*

Several pits on the inner face of the seed. *E. tetrapora.*

**** Seeds irregularly covered with pits or ridges.

† Thin leaved annuals.

‡ Seeds with small deep pits.

Floral leaves very unequal, longer than the internodes. *E. longicruris.*

Floral leaves nearly symmetrical, shorter than the internodes. *E. commutata.*

‡‡ Seeds with broad pits, and ridges between.

Floral leaves connate to the middle; in Texas. *E. Roemeriana.*

Floral leaves connate at the base or to the middle on one side; Pacific slope. *E. crenulata.*

†† Perennials.

‡ Horns of the glands longer than their body.

Seeds punctate pitted; central United States. *E. commutata.*

Seeds with broad shallow pits; Pacific slope. *E. crenulata.*

‡‡ Horns of the glands shorter than their body.

‖ Glands crenate and very short horned, lobes oblong.

¶ Stem leaves widest above the middle.

§ Stem leaves obtuse, floral leaves broader than long.

Glabrous. *E. Palmeri.*

Pubescent. *E. subpubens.*

§§ Stem leaves obtuse, floral leaves as long as broad. *E. lurida.*

§§§ Stem leaves acute. *E. lurida Pringlei.*

¶¶ Stem leaves widest at or below the middle. *E. schizoloba.*

‖‖ Glands semilunate, the horns longer than the teeth, if any, between them, lobes triangular ovate.

¶ Seeds large, broadly truncate at the base, capsules 5 mm. long. *E. chamaesula.*

¶¶ Seeds and capsules smaller, seeds not prominently truncate.

§ Inflorescence compact, internodes not much longer than the floral leaves, stem leaves lance-linear; Mexican. *E. campestris.*

§§ Inflorescence open, internodes longer than the leaves, stem leaves ovate to oblong.

Low, robust; northern. *E. robusta.*

Slender; southern.

Stem leaves ovate to oblong. *E. montana.*

Stem leaves small, lanceolate. *E. odontadenia.*

Stem leaves oblong to linear. *E. brachycera.*

SYNOPSIS OF NORTH AMERICAN SPECIES.

A. *Decussatae.* Stem leaves decussate, entire; glands 4, bicornute, the horns spatulate; lobes parallel veined; stamens and bracts numerous; seeds carunculate.

E. LATHYRIS Linn. Sp. Plant. 457. 1753; Boiss. DC. Prod. **15**^{2}: 99. 1862; Wats. Bot. Calif. **2**: 76. 1880; Gray, Man. 406. 1848; Brit. & Brown, Ill. Flora **2**: 377. 1897; Greene, Man. Bay Region 80. 1894; Pursh, Flora **2**: 607. 1814. *E. decussata* Salisb. Prod. 389. 1796. (fide Index Kewensis). *Tithymalus Lathyris* Hill, Hort. Kew. 172(3). 1768; Kl. & Gar. Tricoc. 95. 1860. *Galarhoeus decussatus* S. F. Gray, Nat. Arr. Brit. Pl. **2**: 256. 1821. *G. Lathyris* Haw. Pl. Suc. 143. 1812. *E. spongiosa* Ledeb. ex Schrank in Syll. Ratisb. **1**: 214. 1824. (fide Index Kewensis). *Epurga Lathyris* Fourr. Ann. Soc. Linn. Lyon n. s. **17**: 150. 1869. (fide Index Kewensis). *Epurga pensylvanica* Gandoger, Fl. Eur. **20**: 70. 1890. *Euphorbion lathyrum* Saint Lager, Ann. Soc. Bot. Lyon **7**: 126. 1880.—Reichenb. Ic. Fl. Germ. *f. 4783;* Brit. & Brown, Ill. Flora *f. 2327;* Pammel, Seed-coats *pl. 12. f. 18d;* Millspaugh, Medic. Plants *pl. 150.*

Annual; stem single, erect, smooth, glaucous, 4 to 10

dm. high; rays 4, 3 to 9 cm. long, many times dichotomous, the alternate branches sometimes abortive; leaves sessile or very short petioled below the cordate or rotund base, linear lanceolate, or sometimes lanceolate, the lower obtuse, mucronate, the upper acute, glaucous, spreading, 8 to 20 mm. wide, 4 to 12 cm. long; umbel leaves nearly similar; floral leaves lance-ovate, subcordate, sometimes subpandurate, more or less parallel veined, acute or acuminate, 1 to 3 cm. wide, 2 to 6 cm. long; involucres 3 to 4 mm. long, pubescent under the glands; lobes ovate, fimbriate, erect and valvate between the glands; glands semilunar, the horns spatulate and usually recurved; sinus deep; sixth lobe small, or none; bracts small, the larger ones fimbriate, a few hairs at the apex; stamens 25 to 40, their pedicels pubescent with a few scattering hairs; styles 2 to 3 times as long as the ovary, 2 mm. long, short bifid above, the stigmatose ends flattened; capsule spherical, fleshy, wrinkled when dry, 8 to 10 mm. in diameter; sulci shallow, cocci obtuse; seeds ovoid, truncate, a broad shallow groove in front, wrinkled, dirty brown colored, with darker spots, 4 to 4.5 mm. long, 3 to 3.5 mm. wide, 3.5 mm. thick; hilum large, white; caruncle round, hat shaped, substipitate. — Introduced from Europe into various parts of the United States and many other parts of the world. It has been found in California, Texas and New Mexico (fide Coulter, Bot. West. Tex. 393.), and in many places along the mountains in the eastern United States where it may possibly be indigenous. — Plate 11.

Specimens examined from Pennsylvania (Parker, Harrisburg, 1865); Virginia (Britton and others, St. Clair's Creek, 1892, Luray, 1890; Small, St. Clair's Creek, 384, 1892; Curtiss, Bedford Co., 1871); California (Peckham, San Buena Ventura, 1866; Leeds, Santa Clara, 1889; Mrs. Brandegee, San Francisco).

Reported also from Monterey, Calif. (Engelm. Bot. Mex. Bound. 193); Texas and New Mexico (Coulter, Bot. West. Tex. 393); upper districts, North Carolina (Curtis, Cat. N. C. Plants 48. 1867); Meriden, Connecticut (Leonard, Cat. Pl. Meriden 29. 1885); West Virginia (Millspaugh & Nuttall, Fl. W. Va. 215. 1896); and from several places in New York and New Jersey by several authors.

B. *Ipecacuanhae.* Lurid colored, usually dioeceous; stems few from a deep perennial root; stem leaves few, entire, with a narrow membranaceous marginal line; the involucres of each sex with rudimentary flowers of the other sex; glands 5, truncate; bracts small and few, or none; calyx well developed, 3-lobed; style fleshy; seeds smooth, without a caruncle.

E. FLORIDANA Chapm. Southern Flora 401. 1860. *E. sphaerosperma* Shuttlew. in Rügel Pl. Exs. 1843 and published by Boiss. in DC. Prod. **15**^{2} : 102. 1862. — Boiss. Icon. Euphorb. *pl. 54.*

Stems 3 to 4 dm. high, usually not branched below the umbel; rays 3 to 4, 2 to 4 times dichotomous, the sterile plants still more branched; rays 3 to 5 cm. long; stem leaves scale-like below to long linear lanceolate above, sessile, slightly narrowed at the base, acute, entire, 3 to 6 mm. wide, 4 to 9 cm. long, reflexed; umbel leaves oblong lanceolate, parallel veined, acute, cordate, 6 to 12 mm. wide, 2 to 5 cm. long; floral leaves similar, but smaller and shorter, 1 to 2 cm. long; involucre 2 to 3 mm. wide, slightly higher, greenish red, a villous spot inside under each gland; peduncle 5 to 12 mm. long; lobes ovate, entire or slightly dentate, densely villous on the edge to almost smooth; glands stipitate, quadrate semilunate, truncate with the edge erose crenate, fleshy, recurved, somewhat concave above, 1 to 1.5 mm. wide, greenish; bracts 5, small, entire, more or less villous; stamens 20 to 25 in staminate involucres; pedicel of pistillate flower 5 to 8 mm. long; calyx lobes ovate lanceolate, acute, 1 mm. long; capsule very depressed ovoid, 6 to 11 mm. across, 4 to 6 mm. high, triangular; sulci shallow; cocci only obtuse; styles 1 to 2 mm. long, united below, short bifid above, slender, subclavate stigmatose; seeds black, depressed globose, 2.5 mm. in diameter, 2 mm. high; chalaza slightly depressed. — Sandy coast plain of west and middle Florida. — Plate 12.

Specimens examined (Rügel, Aspalaga, 1843, *E. sphaerosperma;* Chapman, Gadsden Co., 1835, 1856, 1860; Curtiss, Walton Co., 2479, De

Funiak Springs, 5905, 1897; Rolfs, De Funiak, 173, 1894; Mohr, De Funiak Springs, 1892, Pensacola, 1874).

E. INUNDATA Torrey in Chapm. Southern Flora 402. 1860. Boiss. DC. Prod. **15**^{2} : 102. 1862.

Stems 2 to 5 dm. high, sometimes branched below the umbel; rays 2 to 3, 3 to 6 cm. long, about twice dichotomous in fertile plants, several times in sterile plants; stem leaves few, the lower scale-like, the others linear to oblanceolate linear, acute or mostly obtuse, sessile or attenuate to a short petiole, ascending, 3 to 10 mm. wide, 3 to 10 cm. long; umbel leaves similar or more lanceolate, shorter; floral leaves ovate or ovate oblong, acute or obtuse, rotund or rarely cordate at base; peduncles 1 to 3 cm. long; involucres hemispherical or short turbinate, subpentagonal, 2 to 3 mm. high, broader, hairy beneath the glands inside, reddish, especially at the ends of the lobes; lobes short ovate, subtruncate, lacerate dentate, ciliate, usually longer than the glands; glands irregularly transversely ovate, plane or slightly upturned at the inner edge, the margin rotund to subtruncate, entire or crenate; bracts small, partly adnate to the involucre, ciliate, often obsolete, especially in the fertile involucres; stamens 20 to 25; pedicel of pistillate flower 3 to 6 mm. long; calyx lobes lanceolate or ovate, 1 mm. long; capsule depressed ovoid, subcordate, 5 mm. high, 8 mm. wide; styles 1.5 to 2 mm. long, thick, united at base, bifid above, short clavate stigmatose; seeds ovoid oblong, subquadrate in cross-section, gray, sometimes with small irregular brownish spots, dorsal angle obtuse, base very flat, hilum large, raphe large, yellowish, 2.5 to 3 mm. long, 2 to 2.5 mm. wide, and slightly thicker. — Low pine barren swamps, Alabama to Florida. — Plate 13.

Specimens examined from Florida (Chapman, many forms and collections from Apalachicola and vicinity, first collected in 1836; Buckley, E. Florida; Dean; Palmer, E. Florida, 1874); Alabama (Mohr, Mobile Bay, — pedicels short and glands crenate).

E. TELEPHOIDES Chapm. Southern Flora 402. 1860. Boiss. DC. Prod. **15**^{2}: 102. 1862.

Differs from *E. inundata* as follows: stems thicker, 1 to 2.5 dm. high; leaves broad obovate to oblanceolate, the widest 3 cm. wide, the marginal line conspicuous; umbel leaves no shorter than the rays; floral leaves broad ovate, rotund cordate at base; pedicels shorter; involucre redder; glands more cup shaped; lobes shorter, more entire and more villous on the edges; capsule more cordate. — Sandy pine barrens along the coast in Northwest Florida. Accredited also to Alabama in Mohr, Prelim. List. Plants Ala. 37. 1880. — Plate 14.

Intermediate forms connect this with *E. inundata*, of which species it is scarcely more than a variety.

Specimens examined (Chapman, several specimens of different dates and forms, from Apalachicola; Curtiss, near Apalachicola, 2504).

C. Galarrhoei. **Stem leaves alternate, usually serrulate; lobes with a single vein or pinnately veined; glands 4 or 5, their margins rotund and entire; bracts 5, small; calyx none or discoid; seeds carunculate, usually flattened.**

* **Perennial by a horizontal rootstock; capsule verrucose; glands 5; rays of the umbel 5 or more; seeds ovoid, smooth.**

E. DARLINGTONII Gray, Man. 404. 1848; Chapm. Southern Flora 401; Boiss. in DC. Prod. **15**^{2}: 119; Brit. & Brown, Ill. Flora **2**: 378. *E. pilosa* Pursh, Flor. Amer. **2**: 607. 1814. (not Willd.). *E. nemoralis* Darlington, Flora Cestr. 518. 1837. [2d ed.]. (not Kit.). *E. discolor* Shuttl. in Plantae Rügel, and published by Boiss. in DC. Prod. **15**^{2}: 119. 1862. *E. Darlingtonii glabra* Boiss. in DC. Prod. **15**^{2}: 119. 1862. — Brit. & Brown, Ill. Flora *f. 2328;* Pammel, Seed-coats *pl. 12. f. 16.*

Rootstock 1 to 2 cm. thick, with scars of old stems above as in *Polygonatum;* stem 5 to 10 mm. thick, 6 to 12 dm. high, striate; branches in the axils of the upper leaves numerous, similar to the rays, about as long as the leaves;

rays 5 to 8, 5 to 7 cm. long, 1 mm. thick, 1 to 3 times dichotomous; leaves oblanceolate below to lanceolate above, 5 to 10 cm. long, 2 to 3 cm. wide, obtuse or acute, sessile, but tapering at the base, entire, pinnately veined, white pilose beneath or glabrate, inclined to be in groups along the stem; umbel leaves shorter, ovate oblong, often cordate at base; floral leaves broadly ovate, very obtuse or retuse, cordate or truncate at the base, glabrous, 2 to 3 cm. wide, 1.5 to 2.5 cm. long; involucre 3 to 4 mm. high, pubescent or glabrous outside, more or less pubescent inside; lobes obovate or obcordate, incurved, ciliate, with a few lateral nerves; glands irregularly reniform, 2 mm. wide, 1 mm. long; bracts broad, fimbriate and ciliate, adnate to the involucre below, sometimes more than 5; stamens about 15; filament twice the length of the anther; capsule subglobose, 6 to 8 mm. high, 7 to 9 mm. wide, covered with short warts or almost smooth when mature; styles free or slightly united at base, 2 mm. or more long, short bifid above; stigmas short clavate; seeds ovoid or depressed globose, 3 to 4 mm. long, 3 mm. in diameter, smooth or with a few scattering irregular ridges, flattened at the chalaza, color brown; caruncle depressed conical; raphe prominent. — Southeastern Pennsylvania to North Carolina. Not common. — Plate 15.

Specimens examined from Pennsylvania (Darlington, West Chester, 1819, 1827, 1845; Rothrock and Clarke, Center Co.; Green, Mercersburg, 1847; Porter, Mercersburg, 1850–51; Canby, Amedale, 1866, Chester Co., 1864); New Jersey (Lippincott, Swedesboro, 1894); West Virginia (Millspaugh); North Carolina (Curtis, Yancey or Haywood Co., 1844; Rügel, Blue Ridge, 1841; Vasey, 1878, 1881).

Also reported from south of New Garden, Delaware (Tatnall, Cat. Pl. Newcastle Co., Del. 65. 1860); Mts. Md. and Va. (Pursh, Flora Amer. 2: 607. 1814); New York (Brit. & Brown, Ill. Flora 2: 378. 1897).

E. HIBERNA Linn. A smaller plant than the latter, with ovate lanceolate floral leaves and more verrucose capsules, is given as a ballast plant in the Torrey Bot. Club Cat. of Anthophyta and Pteridophyta reported as growing spontaneously within one hundred miles of New York City 87. 1888; and at Philadelphia (Martindale, Bot. Gaz. 2: 58. 1876).

** Annual or biennial or perhaps sometimes perennial by crown buds; rays 5 or less; glands usually 4, transversely elliptical or subreniform; seeds lenticular or reticulate.

+ Capsules verrucose; seeds lenticular.

++ Leaves more or less pubescent; rays usually 5; seeds smooth, shining, a circular depression at the chalaza.

E. PLATYPHYLLA Linn. Sp. Plant. 460. 1753; Boiss. DC. Prod. **15²**: 133; Brit. & Brown, Ill. Flora **2**: 378. 1897; Gray, Man. 405. 1848. (in part), 434. 1868. [5th ed.]; Macoun, Cat. 425. 1886; Hook. Flor. Bor.-Am. **2**: 140. 1840. (?). *Tithymalus platyphyllos* Hill, Hort. Kew. 172 (4). 1768; Scop. Fl. Carn. **1**: 337. 1772. [2d ed.]. *E. verrucosa* Huds. Flor. Ang. 209. 1798. *E. lanuginosa* Thuill. Flor. Paris. 238. 1799. [2d ed.]. *E. subciliata* Pers. Syn. **2**: 18. 1807. *Galarhoeus platyphyllus* Haw. Pl. Suc. 151. 1812. *E. Coderiana* DC. Flor. Franç. **6**: 365. 1815. *E. pilosa* Torr. Compend. Flor. North. and Mid. States 332. 1826. (?). *E. obtusata* Gray, Man. 388. 1857. (in part); Macoun, Cat. 426. 1886. (?). *E. Tannensis* Hort. Boiss. in DC. Prod. **15²**: 133. 1862. *E. foetida* Schult. in Steud. Nom. 1841. (fide Boiss. DC. Prod. **15²**: 133 1862). *E. paniculata* Tenore, Prod. Fl. Nap. lxviii. (fide Index Kewensis). — Brit. & Brown, Ill. Flora *f. 2330;* Pammel, Seed-coats *pl. 12, f. 17a;* Reichenb. Ic. Fl. Germ. *f. 4758.*

Stem single, erect, strictly annual, sparingly branched below the umbel and sometimes at the base, 1.5 to 5 dm. high; rays 5, rarely 3 or 4, dichotomously or at first umbellately branched, then many times dichotomous; primary rays 2 to 10 cm. long, stem leaves oblanceolate spatulate, acute, or the lower obtuse and obovate, spreading or reflexed, subcordate to petiolate at base, serrulate above, 1.5 to 5 cm. long, 5 to 10 mm. wide; umbel leaves oblong; floral leaves triangular ovate, mucronate, subcordate, about 1 cm. long and wide; involucre 2 mm. high, pubescent

with long hairs inside beneath the glands and sometimes outside, lobes oblong obovate, rounded or retuse, irregularly nerved, ciliate with much shorter hairs than those on the rest of the involucre, incurved; glands 1 mm. long, 1.5 mm. wide; bracts 5 to 10, broad, fimbriate, plumose with long hairs; stamens 10 to 15, filament 2 to 3 times the length of the anther; capsule depressed globose, 2.5 mm. high, 3 mm. wide, hardly sulcate, often pubescent; cocci flattened, short verrucose except a line on the back; styles united below, short bifid at the apex; stigmas clavate capitate; seeds 1.9 mm. long, 1.6 mm. wide, 1.1 mm. thick; caruncle small, flat patellate. — Introduced from Europe into the northeastern United States and Canada, mostly about the lakes in the St. Lawrence river valley. — Plate 16.

Specimens examined from Canada (Macoun, Queenstown, Ont., 1882; Shepherd; Cooper, Niagara); Vermont (Brainerd, Bridport, 1882; Pringle, Shelburn, 1879; Oakes, 1829; Boott, Shelburn Bay, 1855; Addison, 1883); New York (Shattock, Poughkeepsie; Engelmann, Niagara, 1856; Cooper, Niagara; Coville, Niagara, 1886; Sheldon, Oswego, 1880; Paine, 1864); Michigan (Boott, Detroit, 1857; Gillman, Detroit, 1849; Morong, Lake St. Clair, 1893; Dodge, Port Huron, 1894; Castelneau, Saganaw); Pennsylvania (Porter, Erie, 1868; Garber, Erie, 1868).

Var. LITERATA (Jacq.) Koch, Syn. Flor. Germ. 627. 1837. *E. literata* Jacq. Collect. **2**: 340. 1788.

Stouter and more pubescent. — Occurs sparingly at New Orleans, Louisiana (Mellichamp, 1898, 1899; Joor).

++ ++ Rays usually 3; leaves glabrous; seeds without a chalazal depression, reticulate, or usually almost smooth in *E. obtusata*.

= Seeds large, faintly veiny reticulate or smooth, stem leaves obtuse.

E. OBTUSATA Pursh, Flora Amer. **2**: 606. 1814; Boiss. in DC. Prod. **15**^{2}: 134; Chapm. Southern Flora 401; Gray, Man. 388. 1857. (in part), 434. 1868. [5th ed.]; Brit. & Brown, Ill. Flora **2**: 378. 1897; Hook. Fl. Bor.-Am. **2**: 140. 1840. (is probably *E. platyphylla*). *E. Helioscopia?* Ell. Sketch Bot.

S. C. & Georgia **2**: 658. 1824. (?). *Pythius obtusata* Rafin. Fl. Tell. **4**: 116. 1836. (fide Index Kewensis)· *E. platyphylla* Gray, Man. 405. 1848. (in part). *Tithymalus obtusatus* Kl. & Gar. Tricoc. 69. 1860. *E. dictyosperma* Ward, Flora Washington 110. 1881. — Brit. & Brown, Ill. Flora *f. 2329*. Pammel, Seed-coats *pl. 12. f. 17*.

Stem erect, single, branched above, 2 to 5 dm. high; rays 3, rarely 5, 3 to 7 cm. long, several times dichotomously branched, or the first time trichotomously; stem leaves spatulate oblong, obtuse, subcordate, clasping, sessile, serrulate with ascending teeth, thin, 6 to 11 mm. wide, 2 to 5 cm. long; umbel leaves ovate oblong; floral leaves cordate ovate, longer than wide, 1 to 2.5 cm. long, 8 to 16 mm. wide; involucre about 1 mm. high, smooth; lobes short, retuse or 2 to 3 dentate, one-nerved; glands transversely oblong, usually reddish, sometimes bright scarlet; sinus wide and shallow; bracts 5, small and setiform; stamens 5 to 10; capsule depressed globose, 3 mm. high, 4 mm. wide, trisulcate, covered all over with short cylindrical warts; styles free, 1.5 mm. long, slender, cleft one-third of their length; stigmas nearly capitate; seeds lenticular, black-brown, not so shining as in the last species, 1.7 to 2 mm. long, 1.5 to 1.8 mm. wide, 1.2 to 1.3 mm. thick; caruncle thin, flat. — Usually in damp woods and along streams, from eastern Iowa to northeastern Texas and east to Pennsylvania and North Carolina. — Plate 17.

Specimens examined from North Carolina (Canby, Wilmington, 1867; Curtis; Ashe, Chapel Hill, 1897); Missouri (Hasse, Jefferson Co., 1887; Engelmann, St. Louis, 1867); Ohio (Lloyd, Cincinnati, 1884; Aiken, College Hill, 7662, 1898; Rippos, Toledo); Illinois (Engelmann, American Bottoms, 1834, 1838, 1863; Mead, Warsaw, 1843; Vasey, Morris; Bebb, Fountaindale; Eggert, St. Clair, 1877); Arkansas (Engelmann, 1134, 1835); Kentucky (Short, Lexington, 1835); District of Columbia (Vasey, 1883; Rusby, 1890; Ward, Washington, 1879); Virginia (Pursh, Staunton; Britton & Small, Norfolk Co., 1893); West Virginia (Mertz, Wheeling, 1878); Maryland (Knowlton, 1885); Texas (Reverchon, Dallas, 1874, not mature but with the large capsules of this species); Iowa (Burgess, Carbon, 1878, No. 708b of Arthur's Catalogue).

Reported also from Alabama (Mohr, Prelim. List Plants Ala. 36. 1880); and from Johnson Co., Iowa (Fitzpatrick, Proc. Ia. Acad. Sci. **5**: 162. 1898).

= = Seeds dull, brown, superficially reticulate with wall-like ridges.

1. Cymosely branched; capsule short verrucose; low annuals or occasionally biennial.

E. ARKANSANA Engelm. & Gray, Plantae Lindheimer. in Bost. Journ. Nat. Hist. **5**: 53. 1845; Gray, Man. 388. 1857. [2d ed.]. *E. Helioscopia* Torr. Exp. Red Riv. La. Appx. G. Bot. 282. 1854. (?). *E. dictyosperma* Engelm. Mex. Bound. **2**[1]: 191. 1859; Boiss. in DC. Prod. **15**[2]: 135. 1862. (in part); Gray, Man. 434. 1868. [5th ed.] (and of authors generally, not Fisch. & Meyer). *Tithymalus arkansanus* Kl. & Gar. Tricoc. 66. 1860. *E. obtusata* Coulter, Manual 327. 1885. (?).

Annual, or biennial in the South; stem slender, 1 to 3 mm. in diameter, 2 to 5 dm. high, usually more or less branched at the crown and with spreading branches below the umbel; rays 3, 2 to 3 cm. long, many times dichotomously and diffusely branched, the internodes longer than the leaves, the umbel in typical forms not so long as the main stem; stem leaves few, cuneate to spatulate, sessile or the lower petioled, usually almost acute, serrulate, 1 to 3 cm. long, 5 to 10 mm. wide; umbel leaves oblong or ovate; floral leaves broad triangular ovate to oblong, truncate or subcordate at the base, mucronate, serrulate, 1 cm. wide, 1 to 2 cm. long, the upper ones much smaller; involucre 1 mm. or less high, a line of long hairs below the glands inside or almost smooth; lobes very short, rotund or emarginate, long ciliate to smooth; glands transversely elliptical, yellow, less than 1 mm. wide, over .5 mm. long; fifth gland replaced by a very small lobe or a tuft of hairs; bracts 5, fimbriate and long ciliate; stamens 5 to 15, jointed at the base; capsule depressed globose, short verrucose except in the acute sulci, 2.5 to 3 mm. wide, 2 to 2.5

mm. high; cocci flat or rotund; styles free, spreading, less than 1 mm. long, divided to the middle or less, the tips slender; stigmas clavate capitate; seeds ovoid lenticular, brown, or purplish when immature, with low but sharp, close, wrinkled reticulations, 1.3 to 1.5 mm. long, 1.1 to 1.3 mm. wide, .9 mm. thick; caruncle small, flat and thin. — Very variable and with several well-marked varieties. The typical form is found from eastern Colorado to southeastern Kansas, and south to Mexico and Alabama. — Plate 18.

Specimens examined from Colorado (Eastwood, Platte Riv. 1892); Texas (Lindheimer, 302, 1844–6, 167, 1844, 311, 1845; Wright; Jermy, Gillespie Co.; Wurzlow, Industry, 15, 1893; Hall, Houston, 554, 1872, the seed resembling that of *E. leiococca*; Reverchon, Dallas, 1880; Drummond, 328; Joor, Navarro Co., 1880, Richland, 1880); Arkansas (Dr. Pitcher; Engelmann, 281); Indian Territory (Sheldon, Colberts, 15, 40, 1891; Engelmann, Cherokee Nation, 1132, 1835; Bush, Coal Creek, 549, Vinita, 547, 1894; Butler, Limestone Gap, 1877; Bush, Sapulpa, 548, 1894, 1097, 1895, some of the specimens approaching *E. obtusata* in foliage and having red glands); Missouri (Bush, Dodson, 429, 1896, near var. *Missouriensis*); Louisiana (Hale); Alabama (Buckley, 1840; Mohr, Russell Co., 6); Mexico (Wright, Lake Sta. Maria; Berlandier, 2536, 1834).

A robust, large leaved form with more pubescent involucres is represented by Lindheimer, New Braunfels, Tex., 88, 1848 (Plate 18); Carleton, Muskogee, I. T., 20, 1891; and Joor, Navarro Co., Tex., 1880. Heller, Corpus Christi, Tex., 1475, 1894 (*E. obtusata* Heller, Bot. Expl. South. Tex. 61. 1895), is a peculiar plant with many ascending or decumbent branches from a seemingly biennial root. — Plate 19.

Var. MISSOURIENSIS n. var. *E. obtusata* Torr. Ann. Lyc. N. Y. 2:244. 1828; Cat. Plant. Fremont Exp. 96. 1845. *Euphorbia platyphylla* Gray, Pac. R. R. Rept. Stevens Exped. 47. 1860. *E. dictyosperma* of most Eastern floras. — Brit. & Brown, Ill. Flora *f.* *2331;* Boiss. Euphorb. Icon. *pl. 84.* 1866.

Usually larger and more robust than in the typical form;

umbel not so much branched, and branched rarely at the crown; stem leaves more deeply and grossly serrate, more spatulate; floral leaves, at least the lower, oblong, even the upper ones longer than wide; involucral lobes and bracts smooth; seeds purplish brown when ripe, the reticulations more open and regular. — In the Missouri River Valley, usually in open prairie or waste places, from Missouri to South Dakota and west to Colorado and Idaho, and extending into eastern Washington. — Plate 18.

Intergrading with the species proper on the borders of their ranges, and though possessing very marked characters, it seems best retained under *E. Arkansana*.

Specimens examined from Oklahoma (Blankinship, 1896); Colorado (Eastwood, Denver, 1892, 1897); Nebraska (Clements, St. James, 2621, 1893; Rydberg, Lincoln, 1890; ?Fremont Exped., Little Blue, 1842, perhaps a plant of very dry places; Hayden, Red Cedar Island, 1853, with large seeds and much like var. *Coloradensis*); Kansas (Gayle, Ft. Riley, 631, 1893; Bodin, Lindsborg, 1884; Shear, Osborne Co., 95, 120, 1894; Smyth, Hutchinson, 46, 1890; Oyster, Paola, 1883, near the type; Norton, Manhattan, 1897; Hitchcock, Courtland, 1892; Kellerman, 1895; Norton & Clothier, 481, 1895); South Dakota (Hayden, Ft. Pierre, 1853); Iowa (Harvey, Humbolt, 1874; Hitchcock, Iowa City; Parry, Davenport, 1848); Missouri (Bush, Randolph, 586, 1895; Popenoe, 1875); Idaho (Spalding, Clear Water); Montana (Watson, 356, 1880, seeds large; Hayden, Madison River, 1860); New Mexico (Vasey, Las Vegas, 1881); (Dr. James, on the Missouri, Long Exped.; Havard, Yellowstone Riv., 1878; Stevens, Pac. R. R. Exp.).

Also reported from Minnesota (*E. dictyosperma*), Leiberg, Rock Co. (Upham, Cat. Flora Minn. 123, 1884); Moyer, Montevideo (Sheldon, Minn. Bot. Studies 1: 588. 1896).

Many of the northern specimens examined are smaller, less branched, the leaves more obtuse, more serrate, and in dried specimens of a yellowish color. They are: from Idaho (Heller, Lewiston, 3127, 1896; Sandberg, Hatwai Creek, 256, 1892; Henderson, Clear Water Riv., 1894; Spalding, Clear Water, perhaps from Washington); Montana (Kelsey, Helena, 1888; Blankinship, Custer, 70, 1890; Allen, Yellowstone Exped., 1873, seeds large); South Dakota (Rydberg, Hot Springs, 996, 1892); Washington (Brandegee, Wallawalla, 1072, 1883).

Var. COLORADENSIS n. var.

Somewhat intermediate between var. *atrosemina* and var. *Missouriensis;* characterized especially by the elliptical floral leaves. — Mountains of Colorado, Wyoming and Utah. — Plate 19.

The specimens grouped here are much varied and perhaps with better specimens and more material it will be possible to make a better disposal of them. Jones, Clear Creek Cañon, Col., 239, 1878, and Parry, Rocky Mts., 1862, are typical. Others are: Watson, Antelope Island, Utah, 1880, 1869 (a desert form); Hall, 40°, Col., 1868; Cowen, Larimer Co., Col., 454, 1895; Greene, Golden, Col., 362, 1870. Pammel & Stanton, Sheridan, Wyo., 1897, approaches *E. dictyosperma*. Vasey, Colorado, 514, 1868, has nearly the seed of var. *atrosemina*, but has several stems 2 to 2.5 dm. high and covered with broad, spatulate leaves. A specimen in the National Herbarium, probably of the same collection, is similar, but more robust and resembles *E. obtusata*, though without seed.

Var. ATROSEMINA n. var.

Low, 10 to 15 cm. high, branched from the base and along the short stem, obconical in outline; leaves thick, glaucous; involucre almost glabrous; bracts small; capsule with a few short warts on the upper part of the cocci; seeds very dark brown, closely wrinkled with broken irregular ridges. — From Wyoming, south in the mountains to Arizona and New Mexico. — Plate 20.

Specimens examined from Arizona (Pringle, Santa Rita Mts., 1884; Wooton, Concho, 80, 1892; Toumey, Bradshaw Mts., 253, 1892; Rusby, Prescott, 821, 1883); Colorado (Eastwood, Denver, Platte River, 1892, and Grand Junction; Brandegee, Cañon City, 1877, Soda Springs, 550, 1877; Hall & Harbour, 510, 1862, the same from seed at Athens, Ill, is tall and open); Wyoming (Nelson, Mexican Mines, 581, 1894).

E. MEXICANA (Engelm.) n. comb. *E. multicaulis* Engelm. Mex. Bound. **2**[1]: 191. 1859; Boiss. DC. Prod. **15**[2]: 135. 1862. (not Thuillier, Fl. Paris

238. 1779). *E. dictyosperma Mexicana* Engelm. l. c. *E. dictyosperma multicaulis* Coulter, Bot. West. Tex. 393. 1894.

Stems crowded, erect or ascending, strict, many from a biennial or perennial root, 1 to 2 dm. high, reddish, leafy; umbel 3-rayed, not much branched; stem leaves oblong cuneate to linear cuneate, low crenulate, 3 to 5 mm. wide, 1 to 2 cm. long, obtuse to retuse; floral leaves oblong, acutish; involucre about 1 mm. high; lobes short triangular, rounded or bidentate, with a few short hairs on the margin; glands very small; bracts 5 or more, broad, entire or dentate, smooth; stamens 5 to 10; capsules subglobose, trisulcate; cocci rounded, short verrucose on the upper part, 2 to 2.5 mm. high, 2.5 to 3 mm. wide; styles short, free, deeply bifid; seeds lenticular ovoid, brown, finely low reticulate, 1.4 to 1.6 mm. long, 1 to 1.3 mm. wide, .7 to .8 mm. thick. — Southern Arizona to Texas and in Mexico. — Plate 21.

Perhaps only a variety of one of the northern species, but I follow Engelmann and Boissier in retaining it as a distinct species.

Specimens examined from Texas (Wright, El Paso, 1824, 1851–2); ?Arizona (Thurber, seed only in Engelm. herb.); Mexico (Gregg, Mapimi, 456, 462, 1847, and 1848–9; Thurber, Los Playos, 381, 1851).

Palmer, Walnut Grove, Ariz., 510, 1876; and Thurber, Mule Spring, N. M., 282, 1851, are young specimens, doubtfully referred here, as also is Parish, Calif., near Mex. boundary, with very pubescent lobes and bracts.

E. DICTYOSPERMA Fischer & Meyer, Ind. Sem. Hort. Petrop. **2**: 37. 1835; Boiss. DC. Prod. **15²**: 135. 1862. (in part); Watson, Bot. Calif. **2**: 75. 1880; Greene, Man. Bay Region 80. 1894.

Stem stout, 2 to 3 dm. high, 2 to 4 mm. thick, few to several stems from the base, branched; rays 3, several times dichotomously branched, the umbel longer than

the main stem; stem leaves obovate spatulate, or cuneate, the lower short petioled and retuse or even obcordate, the upper rounded at the apex, 8 to 15 mm. wide, 1 to 3 cm. long, almost entire to crenate serrulate; floral leaves ovate elliptical, low serrulate or crenulate, mostly very obtuse, 6 to 10 mm. wide, 10 to 15 mm. long; involucre broad campanulate; lobes and bracts almost smooth or ciliate with a few short hairs; capsule almost globose, 3 mm. in diameter, with many short warts on the upper part; styles 1 to 1.5 mm. long, free, bifid almost to the base; seeds ellipsoid lenticular, yellowish brown, 1.8 mm. long, 1.3 mm. wide, 1 mm. thick, or often smaller, the depth of the reticulations much varied, netted, usually prominent and forming large areolae. — Southern Washington to Lower California, mostly in the interior. — Plates 22, 23.

Specimens examined from Oregon (Howell, Ashland, 1889; Leiberg, Hoover Creek, 135, 1894; Howell, Roseburg, 721, 1887); California (Eastwood, Brentwood, 1893; M. K. C., Amador Co., 1886; Mrs. Brandegee, Alameda Co., 1892; Hartweg, Sacramento Valley, 1951; Stillman, Upper Sacramento; Palmer, Chico, 2082, 1892; Baker, Modoc Co., 1894; Brewer, Nipoma Ranch, 416, 1861; Fitch, in Herb. Torrey; Snyder, La Jolla, 1895; Mrs. Austin, Chico, 128, 1896; K. C., Antioch, 1883; Torrey, New Almaden, 477, 1865; Brewer, Corral Hollow, 1214, 1861, from a dry hill, leaves thick, much branched, internodes long, seeds deeply reticulated; Parry, 14, 1874, like the last but slender and low and with low reticulated seeds; a specimen from the Harvard Botanical Garden from seed from the St. Petersburg Garden is similar).

A slender form, with thinner leaves and often many stems, which occurs mostly in the southern half of California, is represented by the following: Mrs. Brandegee, Santa Catalina Island; Bolander, Mono Pass, 6414, 1866; Davidson, Los Angeles, 1890; Orcutt, Jumal Valley, 1889.

In the southern range of the species the plants are scarcely over one decimeter high; upper leaves more ovate cordate; styles not so deeply divided. The following are of this form: California (Jones, San Luis Obispo, 3482, 1882; Miles, San Luis Obispo); Lower California (Orcutt, 237, 1882; Brandegee, San Enrique, 1889).

2. Racemosely branched below the small umbel; capsule long warted; a tall mountain perennial or biennial.

E. ALTA n. sp. *E. dictyosperma* Engelm. Euphorb. Wheeler's Exped. 248. 1878.

One primary stem, 2 to 6 mm. thick, 2 to 6 dm. high, or often several stems, sometimes as large, from buds at the crown; the many branches along the stem below the umbel longer than the rays; rays 3, 2 to 3 cm. long, several times short dichotomous; stem leaves oblong spatulate, very numerous, close together below, thin, somewhat glaucous, minutely serrulate, obtuse, 1 to 5 cm. long, 7 to 12 mm. wide; umbel leaves more oblong; floral leaves oblong ovate to ovate, subcordate, obtuse, 6 to 10 mm. wide, 10 to 15 mm. long; involucre 1 to 2 mm. high, glabrous except the short, ovate, ciliate lobes; bracts about 5, spatulate, ciliate; stamens jointed below, 5 to 10; calyx discoid; capsule depressed globose, 3 to 4 mm. high, 4 to 5 mm. broad; sulci prominent; cocci almost covered with cylindrical warts 1 mm. or less long; styles free, bifid above, 1 mm. or less long, recurved when young, incurved when old, slender, tapering upward; stigmas capitate; seeds 1.8 to 2 mm. long, 1.6 to 1.8 mm. wide, 1.2 to 1.4 mm. thick, purple black, with lighter colored low reticulations forming large areolae; caruncle small, thin, flat. — In the mountains of southern Arizona and New Mexico, and in Mexico. The specimens seen are all from 5200 to 9800 feet altitude. — Plate 24.

Specimens examined from Arizona (Pringle, Huachuca Mts, 1884; Toumey, Huachuca Mts., 10, 1894; Engelmann, Santa Rita Mts., 1880; Rothrock, Camp Grant, 370, 1874); New Mexico (Wooton, White Mts., 1895, 285, 1897); Mexico (Forrer, near Durango, 1881; Pringle, Sierra di Pachuca, 6960, 1898, very small).

+ + Annual; capsules smooth; floral leaves widest at or above the middle; seeds deeply exsculptate reticulate.

E. LEIOCOCCA (Engelm.) n. comb. *E. dictyosperma leiococca* Engelm. Mex. Bound. 2^1:191. 1859. *E. Texana* Boiss. Cent. Euph. 30. 1860; DC. Prod. 15^2: 137.

1862; Coulter, Bot. West. Tex. 393. 1894. — Boiss. Euphorb. Icon. *pl. 87.* 1866.

Entirely glabrous, stems several from the crown, slender, 10 to 17 cm. high, branched below the 3-rayed umbel; rays 2 to 3.5 cm. long, dichotomous, or trichotomous and then several times dichotomous, stem leaves attenuate cuneate, obtuse, mucronate, crenate near the apex, 8 to 15 mm. long, 2 to 4 mm. wide; umbel leaves similar; floral leaves more elliptical or obovate, somewhat shorter and wider; involucres hemispherical, 1 mm. high; lobes short, bidentate; bracts 5, short; stamens usually 5; glands almost always 5, elongated reniform; capsule depressed globose, 2.5 to 3 mm. wide, 2 mm. high; cocci rounded or somewhat flattened; calyx distinctly discoid or triangular; styles free, spreading, deeply bifid, flattened, 1 mm. long; stigmas small, capitate; seeds brownish black, globose lenticular, about 6 areolae to the length of the seed, a distinct line on the back and a triangular space under the caruncle, 1.5 mm. long, 1.3 mm. wide, 1 mm. thick; caruncle small, low conical. — Southern Texas. — Near *E. Arkansana* and *E. Mexicana*. — Plate 25.

Specimens examined (Hall, Houston, 555, 1872; Joor, 1877; Drummond, 327, "E. Tex.," 1835?; "Hooker, Tex. 14," in herb. Engelmann).

E. Helioscopia Linn. Sp. Plant. 459. 1753; Gray, Man. 405. 1848; Boiss. DC. Prod. **15²**: 136. 1862; Brit. & Brown, Ill. Flora **2**: 379. 1897; Macoun, Cat. 426. 1886. *Tithymalus Helioscopius* Hill, Hort. Kew. 172 (3). 1768; Scop. Fl. Carn. **1**: 337. 1772. [2d ed.]. *Galarhoeus helioscopius* Haw. Pl. Suc. 152. 1812. *Tithymalus serratus* Gilib. Fl. Lituan. **2**: 207. 1781. (fide Index Kewensis). *Euphorbion helioscopium* St. Lager, Ann. Soc. Bot. Lyon **7**: 126. 1880. See *E. obtusata* and *E. Arkansana*. — Reichenb. Ic. Flor. Germ. *f. 4754;* Brit. & Brown, Ill. Flora *f. 2332;* Pammel, Seed-coats *pl. 12. f. 18a.*

Stem single, 1 to 3 dm. high, 3 to 6 mm. thick, slightly

swollen below the umbel, a few long scattering hairs above, sometimes sparingly branched at the base or below the umbel; rays 5, 3 to 4 cm. long, trichotomous, then several times dichotomous; stem leaves spatulate obovate, serrate, obtuse or retuse, the lower attenuate into a petiole, .5 to 4 cm. long, 3 to 15 mm. wide; umbel leaves similar, but larger; floral leaves elliptical or obovate, somewhat oblique, smaller and wider in proportion than the stem leaves; involucre 2 mm. high, pubescent inside beneath the glands with long, straight hairs; lobes small, oblong, fimbriate, ciliate; glands 4, transversely elliptical, yellowish, 1 mm. wide, .5 mm. long; the fifth gland replaced by a small fimbriate lobe; bracts 5, slender, 1 mm. long, plumose at the apex with long hairs; stamens about 15; capsule subglobose, cordate below, smooth, 2.5 to 3 mm. high, 3.5 to 4 mm. wide; cocci rotund; sulci deep; styles 1 mm. long, free, bifid above, clavate stigmatose; seeds ovoid subglobose, acute at apex, yellowish brown; 2 mm. long, 1.5 mm. in diameter; areolae on the surface .2 to .3 mm. wide, their walls prominent, caruncle transversely elliptical, vertical. — Waste places in the lake regions of the northeast United States and Canada. Introduced from Europe. — Plate 26.

Specimens seen from Canada (Short, 1852; Fowler, Kingston, Ont., 1885; Allen, River du Loup, Queb., 1890; Northrop, Notre Dame du Lac, 225a, 1887); Pennsylvania (Martindale, Philadelphia, 1876; Porter, Erie, 1868); New York (Paine, L. Onondago, 1864; Clinton, Buffalo; Coville, Norwich, 1886; Troy; Sartwell, Penn Yan and Lake Erie; Hayden; Kennicott, Buffalo); Michigan (Rusby, Detroit, 1884; Wheeler, Mackinac Is., 1881, 1892; Millspaugh, Mackinac Is., 1898; Holton, Mackinac Is., 1850); Maine (Fernald, Farmington, 1894); Ohio (Sartwell, Maumee; Werner, Painesville, 1891, 1892); Illinois (Hall, Athens, 1867); Vermont (South Haven, 1896).

Also reported from Illinois (Patterson, Cat. Pl. Ill. 37, 1876); and Pictou, Nova Scotia (Sommers, Flora Nova Scotia 207).

D. *Esulae.* Stem leaves alternate, usually entire; glands 4 or 5, their outer edge not rotund, entire, usually more or less bicornute; calyx inconspicuous, triangular or discoid, seeds carunculate, oblong or ovoid, circular or rhombic in cross-section.

* Main stem short; leaves crenulate, most of those in the tricho-

tomously branched umbel alternate; bracts many; seeds ovoid, smooth; caruncle small.

E. TRICHOTOMA Kunth in Humbolt & Bonpland, Nov. Gen. **2**: 60. 1817; Boiss. DC. Prod. **15²**: 105. 1862; Chapm. Southern Flora 402. 1860. *E. dumosa* Rich. in Sagra, Cuba **11**: 198. 1850. *Tithymalus trichotomus* Kl. & Gar. Tricoc. 81. 1860. *E. Sagraeana* Rich. MS. in Boiss. Euph. in DC. Prod. **15²**: 105. 1862. — Boiss. Icon. Euph. *pl. 58.*

Glabrous throughout, somewhat woody, many stems erect from the root, branched at the base, then after an interval 3- or 4-chotomous; 2 to 5 dm. high; the first branches 3 to 5 cm. long; leaves all alike, crowded, obovate or lanceolate, obtuse or acute, sessile, 5 to 12 mm. long, 2 to 4 mm. wide; involucres few, 2 mm. wide, subglobose, not membranaceous, pubescent inside, especially below the glands; lobes incurved, short oblong, dentate, hirsute to smooth; glands semilunate, dentate between the short horns, spreading, stipitate, 1 mm. wide, yellow; bracts fimbriate and hirsute or ciliate; stamens about 10, filaments very short; capsule depressed ovoid, 4 mm. wide, 3 mm. high; cocci rotund, minutely papillose; sulci deep; pedicel 4 to 8 mm. long, smooth; style very short, clavate stigmatose, shortly bilobed; seeds ovoid globose, 1.6 mm. wide, 1.8 mm. long, white, a slight ridge on the back; raphe large and black; chalaza flat; caruncle very small. — Florida, West Indies and Eastern Mexico. — Plate 27.

Specimens examined from Florida (Chapman, Little Sarasota Bay, 1875, Key West, 1886; Curtiss, Jupiter Inlet, 5539, 1895, Cape Malabar, 2502; Nash, Tampa, 2421, 1895; Palmer, Key West and Indian River, 506, 1874; Leavenworth, Tampa, 1829; Garber, Manatee, 1878; Herb. Thurber, E. Fla.; Blodgett, Pine Key and Key West; Merrill, Key West, 1886); Cuba (Herb. Bernhardi, Matanzas; Reichenbach; Wright, 354); Yucatan (Gaumer, 1885).

** Rays dichotomously branched; floral leaves opposite; glands usually 4; bracts few, usually 5, sometimes obsolete; caruncle well developed.

+ Thin leaved wood or field annuals or biennials with fibrous roots;

glands crescent shaped, horned; capsules subglobose; seeds variously marked, more or less flattened or angled.

++ Floral leaves acute or acuminate, very inequal; capsular angles almost acute; styles .5 mm. long; seeds tuberculate.

E. EXIGUA Linn. Sp. Plant. 456. 1753; Boiss. DC. Prod. 15^2 : 139. 1862; Greene, Man. Bay Region 80. 1894. *Tithymalus exiguus* Hill, Hort. Kew. 172 (3). 1768; Lam. Fl. Fr. **3**: 100. 1778. (fide Index Kewensis). *Esula exigua* Haw. Pl. Suc. 158. 1812. *Keraselma exigua* Rafin. Fl. Tell. **4**: 116. 1836. (fide Index Kewensis). — Reichenb. Ic. Flor. Germ. *pl. 4777.*

Simple or branched from the base, 1 to 2.5 dm. high, striate, branched below the umbel; rays 3 to 5, many times dichotomous, 2 to 3 cm. long; stem leaves 1 to 10 mm. apart, entire or minutely tuburculate serrulate, acute or obtusish, sessile, 1 to 2 mm. wide, 3 to 25 mm. long; umbel leaves similar, but dilated at the base; floral leaves lanceolate, connate on one side, sometimes with a large tooth on that side, 2 to 4 mm. wide, 6 to 12 mm. long; involucral lobes triangular ovate, truncate, acute or bidentate, smooth, erect or incurved; glands transversely oval, the two next the sinus larger; horns as long as the width of the gland, diverging from beneath the gland; fifth gland replaced by a very small lobe or none; bracts small, filiform, smooth; stamens 5 to 10; capsule ovoid, almost triangular, 1.5 to 2 mm. in diameter; styles free, bifid, clavate stigmatose; seeds quadrangular ovoid, slightly flattened, the inner faces concave, angles almost acute, 1.2 mm. long, .7 to .8 mm. wide, or as much as 1.5 mm. long in large plants; caruncle small, low conical.—Sparingly introduced from Europe in a few localities. — Plate 28.

Specimens examined from New Jersey (Buck, Kaighn's Point, 1866); New York (Day, Buffalo, 1896; also as ballast plants about New York City); California (Leeds, Santa Clara, 1888).

++ ++ Leaves obtuse; capsular angles rotund; styles 1 mm. long; seeds smooth or microscopically tuberculate.

E. HELLERI Millspaugh, Bot. Gaz. **26**: 268–270. *f.* 28

1898. *E. commutata* Coulter, Contrib. Nat. Herb. **1**: 48. 1890. *E. tetrapora* Heller, Bot. Explor. South. Tex. 61. 1895.

Many stems from the crown, a few branches below the umbel, 15 to 25 cm. high, smooth; rays 3, 3 to 5 cm. long, many times dichotomous with long internodes; stem leaves spatulate, obtuse or retuse, petioled, 6 to 15 mm. long, 3 to 5 mm. wide; umbel leaves oblong, almost sessile; floral leaves orbicular ovate, subpandurate, unequal, obtuse, mucronate, broad cuneate to truncate at base; involucre about 1 mm. long; lobes incurved, ovate, truncate, ciliate; glands elliptical, about twice as wide as long, horns as long as the body of the gland; fifth gland similar to the lobes but shorter; bracts filiform, a few hairs at the tip; stamens about 10; capsule depressed globose, 2.5 mm. high, 3 mm. wide; cocci flattened, smooth; styles slightly united at the base; stigmas clavate, recurved; seeds ovoid, white, inner faces flattened, an indistinct angle on the back, 1.4 to 1.6 mm. long, 1 to 1.2 mm. wide, almost as thick; caruncle thin but raised into a cone, bilobed. — Southern Texas. — Plate 29.

Specimens examined (Heller, Corpus Christi, 1509, 1894; Nealley, Brazos Santiago, 71=442, 1889).

↔ ↔ ↔ Capsular angles decidedly obtuse; seeds marked with pits, some of which are in rows.

= Capsule bicrested on the back of each coccus.

E. Peplus Linn. Sp. Plant. 456. 1753; Boiss. DC. Prod. **15**^{2}: 141. 1862; Pursh, Flor. Amer. **2**: 606. 1814; Gray, Man. 405. 1848. (in part); Macoun, Cat. 426. 1886; Greene, Man. Bay Region 80. 1894; Brit. & Brown, Ill. Flora **2**: 379. 1897. *Tithymalus Peplus* Hill, Hort. Kew. 172 (3). 1768; Gaertner, Fruct. **2**: 115. 1791. *T. rotundifolius* Lam. Fl. Fr. **3**: 100. 1778. (fide Index Kewensis). *Esula Peplus* Haw. Pl. Suc. 158. 1812. *E. minima* Haw. l. c. *E. rotundifolia* S. F. Gray, Nat. Arr. Brit. Plants **2**: 257. 1821.

Keraselma oleracea Rafin. Fl. Tell. **4**: 116. 1836. (fide Index Kewensis). *K. Peplus* Rafin. l. c. *Euphorbion peplum* St. Lager, Ann. Soc. Bot. Lyon **7**: 125. 1880. — Reichenb. Ic. Fl. Germ. *f. 4775;* Brit. & Brown, Ill. Flora *f. 2333;* Pammel, Seed-coats *pl. 12. f. 18e.*

Many branches from the base and below the umbel; stem 12 to 30 cm. high, erect or ascending, the lower branches often almost as high as the axis, striate; rays 3 to occasionally 5, 1.5 to 4 cm. long, many times branched; cotyledons elliptical; stem leaves obovate or rotund, obtuse or retuse, very thin, crisped, 5 to 25 mm. long, 4 to 12 mm. wide; petioles 1 cm. or less long; umbel leaves little different, sessile; floral leaves somewhat oblique, ovate, slightly pandurate, obtuse at both ends, sometimes mucronate, 5 to 10 mm. wide, 6 to 15 mm. long, involucre about 1 mm. high and wide; lobes triangular ovate, ciliate with short thick hairs; glands .5 mm. long, one-half wider; horns much longer, spreading, the two next the sinus longest; bracts flattened filamentous, ciliate at the end; stamens 10 to 15; capsule depressed globose, 2 to 2.5 mm. in diameter; cocci rounded; sulci deep; styles only .5 mm. long or less, free, deeply bilobed; seeds white, ovoid oblong, sub-hexagonal, 1.3 mm. long, .8 mm. wide, the two inner faces each with a large longitudinal sulcus, the four external each with about 3 large shallow pits in longitudinal rows, sometimes additional pits between the rows, or even 6 rows; caruncle conical, white. — Introduced from Europe into the northern United States and Canada from Wisconsin to Nova Scotia, south to Iowa and New Jersey; also in California and Alabama. — Plate 30.

Specimens examined from New York (Brown, New York, 1879, 1880, ballast; Coville, Oxford, 1884; Clute, Binghamton, 1896; Day, Buffalo, 1845; Haberer, Utica, 1883); California (Leeds, Santa Clara, 1889, 1888; Michener & Bioletti, Berkeley, 1892); New Jersey (Parker, Camden, 1866, ballast); Pennsylvania (Wolle, Bethlehem, 1846; Porter, Lancaster, 1861, floral leaves petioled; Small, Lancaster, 1895); Maine (Furbish, Brunswick, 1891); Massachusetts (Sprague; Boott, Boston, 1853);

Illinois (Hall, Athens); Wisconsin (Trelease, Madison, 1882; Kellerman, Oshkosh, 1878); Ontario (Macoun, Ottawa, 1892); Nova Scotia (Burgess, Pictou, 1883); Ohio (Spence, Springfield, 1879; Mosely, Sandusky, 1895); Alabama (Mohr, Mobile, 8); Iowa (Reppert, Muscatine).

Also reported from Rhode Island (Tweedy, Bull. Tor. Bot. Club **9**: 23. 1882; San Bernardino, Cal. (Parish, Erythea **3**: 61); and Monterey and San Francisco, Cal. (Hook. & Arn. Bot. Beechey's Voy. 159, perhaps *E. crenulata*).

== Capsule smooth or with very slight ridges on the back of the cocci.

E. PEPLIDION Engelm. Mex. Bound. **2**[1]: 191. 1859; Boiss. DC. Prod. **15**[2]: 142. 1862; Coulter, Bot. West. Tex. 394. 1894. — Boiss. Icon. Euph. *pl. 93*.

Stems erect, 1 to several from buds at the crown, slender, striate, 5 to 20 cm. high, a few branches just below the umbel; rays 3, 1 to 2 cm. long, a few times dichotomously branched; stem leaves linear cuneate, obtuse or the upper sometimes acute, tapering to a petiole, close together on the stem, 5 to 20 mm. long, 1 to 4 mm. wide; umbel leaves linear or lanceolate or spatulate, dilated at the base, 12 to 20 mm. long; floral leaves rhomboid lanceolate to ovate, falcate, acute, somewhat erose margined; involucre broad turbinate, less than 1 mm. high; lobes deeply cut, dentate, obovate, ciliate; glands stipitate, .2 mm. long, .5 mm. wide, horns much longer; bracts very small or obsolete, a tuft of hairs at the apex; stamens 5 to 10; capsules depressed globose, 2 mm. high, 3 mm. broad, smooth; cocci flattened on the back; sulci deep; styles .5 mm. long, free or nearly so, divided almost to the base; seeds oblong, diagonally truncate above, subhexagonal, 1.3 mm. long, .9 mm. wide, the inner faces with one large depression each, the four outer with 2 to 3 depressions each, or these sometimes irregularly arranged; chalazal depression large; caruncle flat, umbonate, bilobed. — Sandy and stony places in central and southern Texas. — Plate 31.

Specimens examined (Wright, Austin, 1850, east of the San Pedro, 1823, 1851; Hall, Austin, 557, 1872; Reverchon, Upper Concho, 136, 1354, 1882; Berlandier, 1664; Croft, San Diego, 74, 1885, the stem winged; Reverchon, Sabinal, 141, 1885).

E. TETRAPORA Engelm. Mex. Bound. **2**[1]: 191. 1859; Boiss. DC. Prod. **15**[2]: 142. 1862; Chapm. Suppl. South. Flora 646. 1883; Coulter, Bot. West. Tex. 394. 1894. *E. tetrapora Berlandieri* Boiss. DC. Prod. **15**[2]: 142. 1862. *E. peplidion* Holzinger, Cont. U. S. Nat. Herb. **1**: 216. 1892.

Stem erect, simple or with a few branches from the crown and below the umbel, 7 to 25 cm. high; rays 3, 1.5 to 3 cm. long, several times branched; cotyledons ovate elliptical, 3 to 5 mm. long, 2 to 3 mm. wide, with a petiole 2 mm. long; stem leaves cuneate spatulate, attenuate into a petiole, retuse or obcordate, the lower 1 mm. wide and 3 mm. long, 7 mm. wide and 20 mm. long above; internodes one-third as long; umbel leaves more obovate; floral leaves triangular ovate, mucronate, truncate or cordate at the base, subconnate, sometimes subpandurate, 7 to 14 mm. wide, 5 to 10 mm. long; involucres about 1 mm. high and broad, smooth except the ovate lobes which are short ciliate; glands 1 mm. wide, less than half as long, short stipitate; horns about 1 mm. long, diverging or usually erect; fifth gland replaced by a small lobe; bracts very small; stamens 10 to 15; capsules subglobose, 2.5 mm. in diameter; cocci rounded or somewhat flattened with a low ridge on each side the dorsal suture; styles .5 to 1 mm. long, united at the base, short bifid at the apex, capitate stigmatose; seeds oblong, slightly flattened, microscopically tuberculate, 4 to 6 large shallow pits on the inner faces, these sometimes confluent into irregular oblong grooves; the back with 15 to 20 irregularly arranged shallow pits or almost smooth, 1.3 to 1.4 mm. long, .8 to .9 mm. wide, .7 mm. thick; caruncle hat shaped, usually large. — Indian Territory to Texas, east to Georgia. — Plate 32.

Specimens examined from Texas (Reverchon, Dallas, 884, 1881, 1876; Lindheimer, 1839; Wright; Thuron, Hockley, 3, 1889; Jermy, Gillespie Co., 162; Joor, Houston, 1877; Wurzlow, Industry, 15, 1893); Indian Territory (Palmer, 298, 1868); Louisiana (Hale, Red River).

Also reported from Georgia (Chapman, Bot. Gaz. **3**: 12. 1878).

The more pitted form (var. *Berlandieri* Boiss.) is represented by Hall, Houston, Tex., 556, 1872; Joor, Tex., 1880; Mohr, Alabama; Bush, Sapulpa, I. T., 1194, 1895; Carleton, Oklahoma City, Okla., 126, 1891. The last two have a more compact inflorescence, stouter growth and thicker leaves. Boissier gives Berlandier, 1664, near Bejar, Tex., as the type of the variety (DC. Prod. **15²**: 142. 1892).

++ ++ ++ ++ **Seeds covered with irregularly arranged pits or broad ridges.**

= **Seeds white, pitted with 50 to 100 small, deep pits.**

E. LONGICRURIS Scheele, Linnaea **22**: 152. 1849; Boiss. DC. Prod. **15²**: 142. 1862; Coulter, Bot. West. Tex. 394. 1894. *E. peploides* Nutt. Trans. Am. Phil. Soc. n. s. **5**: 172. 1837. (not Gouan); Engelm. Mex. Bound. **2¹**: 191. 1859. *E. Lindheimeriana* Engelm. MS., Boiss. in DC. Prod. **15²**: 142. 1862.

Stems one or more with a few branches later below, 1 to 2 dm. high, branched below the 3-rayed umbel; rays 1 to 3 cm. long, many times dichotomous, with very short internodes; stem leaves 1 to 8 mm. apart, cuneate spatulate below to obovate above, 2 to 6 mm. wide, 5 to 15 mm. long, mucronate, obtuse to retuse, the lower petioled; umbel leaves obovate; floral leaves usually imbricated, reniform or semi-orbicular, slightly connate, very unequal, 7 to 13 mm. wide, 4 to 7 mm. long; involucre 1.5 to 2 mm. high, 1 to 1.5 mm. long; lobes oblong, minutely ciliate; glands crescent shaped, the very broad horns twice as long as the body, erect, and sometimes lobed; stamens 10 to 15; bracts filiform, pubescent at the tip; capsule ovoid spherical, subcordate, 2.5 mm. long, 2.5 to 3 mm. wide; calyx a conspicuous disc; styles .5 mm. long; seeds oblong, slightly flattened, 1.5 mm. long, 1.1 mm. wide, 1 mm. thick, a slight ridge on the back; diameter of the pits less than one-half the space between them; chalazal projection prominent; caruncle small, depressed conical, umbonate. —

Indian Territory and Arkansas to southern Texas. — Plate 33.

Specimens examined from Arkansas (Nuttall); Indian Territory (Sheldon, Caddo, 39, 1891; Palmer, 298, 1868); Texas (Orcutt, Santa Anna, 90; Wright, 1822, 1851–52, 1849; Nealley, 1888, 1890; Hall, Austin, 558, 1872; Drummond, 331; Lindheimer, 17, 331, 529, 313, 698, 90, 1845–48; Pope; Joor, Navarro Co., 1880; Jermy, Gillespie Co., 161, 186).

E. COMMUTATA Engelm. in Gray, Man. 389. 1856. [2d ed.]; Brit. & Brown, Ill. Flora **2**: 380. 1897; Chapm. Southern Flora 401. 1860; ? Macoun, Cat. 426. 1886. *E. Peplus* Gray, Man. 405. 1848. (in part). *E. Ohiotica* Steud. & Hochst. in Frank Pl. Amer. Exs. 1857, published first by Boissier in DC. Prod. **15**^{2}: 142. 1862. *Tithymalus commutatus* Kl. & Gar. Tricoc. 82. 1860. — Brit. & Brown, Ill. Flora *f. 2334;* Pammel, Seed-coats *pl. 12. f. 19.*

Annual, or perennial by new stems arising from the decumbent base of those of the previous year, which persist over winter; 1.5 to 3 dm. high, ascending; stems one to many, branched below the umbel, often many short sterile leafy branches below; rays 3, 3 to 6 cm. long, many times dichotomously branched; stem leaves obovate, obtuse or retuse, the lower tapering into a petiole sometimes 1 cm. long, 5 to 30 mm. long, 3 to 10 mm. wide; leaves on sterile branches oblanceolate, almost acute; umbel leaves wider, ovate cordate or elliptical; floral leaves broad triangular reniform, subconnate, subcordate or the upper ones only truncate, 10 to 20 mm. wide, 5 to 12 mm. long; involucres 1 to 2 mm. high and wide, whitish, glabrous except the oblong, ciliate lobes; glands 1 to 1.5 mm. wide, less than 1 mm. long, yellow or brown when old, with slender white horns twice as long, often toothed between the horns; fifth gland replaced by a small triangular lobe; bracts very small; stamens 10 to 15; capsules ovate globose, 3 mm. in diameter; cocci somewhat flattened on the back, faintly punctate; styles slender, united at the base, deeply bifid above, 1 mm. long; stigmas capitate;

seeds oblong or sometimes subglobose, slightly flattened, 1.8 mm. long, 1.4 mm. wide, 1.2 mm. thick, white, sometimes a row of larger pits on each side the raphe; caruncle depressed conical, short stipitate, nearly as broad as the seed. — Along water-courses and in moist sandy woods, Pennsylvania to North Carolina and west to Wisconsin and Texas. Also in Montana, and a variety in Florida, and will perhaps be found in the intervening States. Perhaps connecting with *E. crenulata* in the northern part of the latter's range, but separable, in all specimens examined with mature seeds, by the surface markings of the seeds. — Plate 34.

Specimens examined from Missouri (Eggert, St. Louis, 1879; Bush, Wayne Co., 1893, McDonald Co., 1891, Shannon Co., 1888, 1891, Eagle Rock, 73, 1897, Bismark, 1893; Trelease, St. Francois Co., 870, 871, 1897; Glencoe, Pammel; Mrs. Brent, Crystal City, 1897; Pammel, Allenton, 1887; Tracy, 1886; Letterman, Allenton, 1875, 1899; Engelmann, St. Louis Co., 1835, 1845; Mann, Wright Co., 1891; Dewart, Potosi, 84, 1892); Illinois (Bebb, Fountaindale, 1870, Ogle Co., 1856, Byron; Munroe, Riverside, 71, 1874; Herb. Babcock, Chicago; Vasey, Dixon, 1861); Virginia (Redfield, Giles Co., 7362, 1876; Curtiss, Roanoke Co., 2471, 1872; Buckley, James Riv., 1838; Brown et al., Roanoke, 1890); District of Columbia (Steele, 1896; Vasey, 1873, 1882; Coville, 1890); Ohio (Frank, 1835, *E. Ohiotica;* Riddell, Cincinnati; Sullivant, Columbus, 1840; Lapham, Columbus, 1835; Riddell, Worthington; Kellerman, Union Co., 1897, Franklin Co., 1894, Licking Narrows, 1894; James, Loveland, 1878; Werner, Franklin Co., 1892; Classen, Marblehead, 1891); Indiana (Canby, Madison, 15, 1863); Kentucky (Palmer, Bullett Co., 1888; Short, Lexington, 1831, 1835); Texas? (Heller, 1573); Pennsylvania (Sandberg, Susquehanna, 1882; Heller, Lancaster Co., 1891; Porter, Lancaster Co., 1858–61; Small, Safe Harbor, 1891; Heller, Safe Harbor, 1890); Montana (Ward, 1882); West Virginia (Heller, Mt. Crawford, 814, 1893); Virginia (Harper's Ferry); Wisconsin (Hale, Beloit, 1861); Tennessee (Gattinger, Nashville, 1882; Bicknell, Nashville, 1894; von Schrenk, Murfreesborough, 1899, in flower Mar. 16); Iowa (Holway, Decorah, 1893); Georgia (Nuttall).

Also reported from Michigan (Winchell, Rept. Geol. Surv. Mich. 291, 1861; Wheeler & Smith, Cat. 67, 1881) and Alabama (Mohr, Prel. List Pl. Ala. 36. 1880).

Var. ERECTA n. var.

More erect and strict in habit; stem leaves more lanceolate and long petioled; apparently strictly annual. — Florida.

Represented by Chapman, Apalachicola, 1836; Croom, 1836; Curtiss, Chattahoochee, 2471; Canby, Hibernia, 1869.

= = Seeds pitted with broad shallow pits with wide ridges between; leaves more or less connate.

E. ROEMERIANA Scheele, Linnaea **22**: 151. 1849; Boiss. DC. Prod. **15**^{2}: 143. 1862; Coulter, Bot. West. Tex. 394. 1894. — Boiss. Icon. Euph. *pl. 94.* 1866.

Stems few, or later some small ones from the base, branched below the umbel, slender, 1.5 to 3 dm. high, .7 to 2 mm. in diameter; rays 3, ascending, 5 to 7 cm. long, 3 or 4 times branched, with long internodes; leaves far apart, obtuse or retuse or obcordate below, abruptly narrowed into a petiole 3 to 5 mm. long, very thin, 5 by 5 mm. below to 10 mm. wide, 20 mm. long above; umbel leaves ovate, very obtuse, 7 mm. wide, 15 mm. long or larger; floral leaves semi-circular, connate to the middle, 10 to 20 mm. wide, 7 to 10 mm. long; involucre campanulate, very thin, 1.5 to 2 mm. high; lobes broad oblong, minutely ciliate; horns of glands shorter than the body, usually incurved; glands 1 mm. wide, 1 mm. long including the horns; bracts insignificant; capsule subglobose, 3 mm. in diameter; styles 1.5 mm. long; seeds oblong ovate, somewhat flattened, dimensions 1.6 to 1.8 mm. by 1.4 to 1.5 mm. by .9 mm., rather deeply broad pitted; chalazal space prominent; caruncle small, low conical, umbonate. — Southern Texas. — Plate 35.

Specimens examined (Lindheimer, New Braunfels, 89, 528, 699, 1846–7; Wright, Blanco).

E. CRENULATA Engelm. Mex. Bound. **2**^{1}: 192. 1859. *E. leptocera* Engelm. in Torr. Bot. Whipple Exped. Pac. R. R. Reports **4**: 135. 1856. (name only); Boiss. DC. Prod. **15**^{2}: 143. 1862; Watson, Bot. Calif. **2**: 75. 1880; Greene, Man. Bay Region 80. 1894. *E. lep-*

tocera crenulata Engelm. in litt. in Boiss. DC. Prod. 15²: 143. 1862.

Stems few to several, 1.5 to 3 dm. high, 2 to 4 mm. thick, branched below the umbel, erect or declined at base; rays 3 to 5, 2 or 3 times branched, 2 to 5 cm. long; leaves crowded below, 1 to 2 cm. apart above, spatulate to obovate, acute to retuse, 10 to 20 mm. long, 3 to 10 mm. wide, tapering to a petiole 2 to 3 mm. long, or sessile; umbel leaves wider, obovate to ovate; floral leaves triangular ovate, base truncate, connate, especially on the outside, or nearly free, 10 to 20 mm. wide, 7 to 11 mm. long or sometimes larger, all the leaves usually erose denticulate; involucre 2 mm. high, 1 mm. wide; lobes truncate or dentate; glands 2 mm. wide, 1 mm. long, the white horns as long or longer, diverging; bracts thread-like, lobed or entire, smooth or sometimes pubescent; capsule 2.5 to 3 mm. long, 3.5 to 4 mm. wide; styles 1.3 to 2 mm. long, slightly united at the base; seeds oblong ovoid to nearly spherical, truncate above, slightly flattened on the inner face, covered with irregular vermiculate ridges and large shallow pits to occasionally tuberculate or even almost smooth, a prominent ridge on the back, white or brownish. — Common mostly in the central valleys of California; also in Oregon, southern California, Arizona, and Colorado. The Oregon forms approach *E. commutata*. — Plate 36.

Specimens examined from California (Hansen, Elsie's Creek, 1094, 1895, 274, 1894; Brown, Shasta Co., 291; Dodd, Yosemite, 1891, seed almost tuberculate; Brandegee, Santa Inez Mts., 1888; Eastwood, Millwood, 1896, Sansalito, 1896; Blaisdell, Big Trees, 40; Eisen, Fresno, 1879; Fritchey, Yosemite, 57; Baker, Modoc Co., 1893; Bigelow, Grass Valley, 1853–4; Wilkes Exped., San Francisco, 1404; Newberry, La Pagosa, 1859; Palmer, Marin Co., 2409, 1892; Mt. Shasta, 2486, 1892; Brown, Sisson, 291, 1897; Austin, Colby, 268, 1896; Ames, Plumas Co., 1875; Bridges, 296; Hartweg, 1950; Cooper, Santa Inez Mts., 1879; Peckham, Ojai; Lemmon, Calaveras Grove; LeConte, Mt. Shasta, 1882; Hansen, Amador Co., 1095, 1892, 1067, 1895, 1977, 1896; Parry, 1874; Rattan, Sierra Nevada; Brewer, 618, Monterey, 1860–62; Nuttall; Wrangel; Pringle, Santa Cruz Mts., 1882; Vasey, Santa Lucia Mts.); Oregon (Hall, 1871; Howell, Milwaukee, 300, 1880, Umpqua Valley, 87, 1881); Arizona (Lemmon, Rucker

Valley, 578, in part, 1881); Colorado (Baker, Earle & Tracy, Mancos, 23, 1898).

On the southern coast of California and the adjacent islands occurs a large form with large deeply cordate floral leaves. Specimens examined that may be referred here are: Vasey, Angel Island, 1875; Brewer, Atascadero, 516, 1861; Trask, Santa Catalina Island, 1896–7. Several of the inland specimens approach these in size and leaf form.

Var. FRANCISCANA n. var.

Seemingly perennial, several to many stout stems from a perpendicular rootstock (?), 3 to 6 mm. in diameter, and tapering into the root; inflorescence smaller; leaves oblanceolate, acute, or the upper obtuse, thicker, whitish beneath; glands darker, larger; capsule depressed ovate, 3 mm. long, 4 mm. wide; styles 1 mm. or more long. — In the San Francisco Bay region, whence the name. — Plate 37.

Specimens examined (Bolander, San Francisco, 20, 1865, cult. fields; Brewer, Oakland, 2762, 1864; Kellogg, Lone Mt. Cemetery, 1877; Jones, San Francisco, 3249, 1882; Kellogg & Harford, Alameda, 898, 1869; Eastwood, San Francisco, 1895).

E. SEGETALIS Linn. Sp. Plant. 458. 1753. Stem leaves linear, the upper dilated at the base; glands semilunar with long spreading horns; capsules with small warts on the back; seeds deeply and finely reticulate with broad white ridges. — Occurs frequently as a ballast plant on the Atlantic coast, but not known to be established.

+ + Perennial; root large; new growth formed from buds at the base of the old stems, which might in some cases be called perpendicular rootstocks; stems more or less woody and scaly at the base; leaves thick; capsules slightly narrowed below the apex, which contains the conical caruncles of the seeds; seeds vermiculate and shallow pitted to almost smooth. A group of closely related plants of the mountains and arid regions of the southwest; not easily separable and often passing into one another on the borders of their ranges.

++ Usually red when young; lobes usually oblong, truncate or incised; bracts mostly broad and prominent; glands large, fan shaped or truncate, crenate margined, scarcely horned; seeds usually with oblong or irregularly shaped pits.

= Stout plants; stem leaves broadest above the middle; leaves microscopically granulate.

E. LURIDA Engelm. Proc. Amer. Acad. **5**: 173. 1861; Boiss. DC. Prod. **15**^{2}: 102. 1862.

Stems several to many, 1.5 to 3 dm. high, rather strict. A few branches below the umbel; rays 12 to 20 mm. long, a few times branched; stem leaves close together, oblanceolate to obovate, sessile or subpetioled, almost always obtuse but with a small mucron, 8 to 15 mm. long, 3 to 5 mm. wide; umbel leaves wider; floral leaves rotund to oblanceolate, more or less cuneate at base, mucronate; involucres 2 mm. long and slightly narrower, more or less hirsute inside; lobes triangular ovate, hirsute; glands transversely oblong, variable in shape, usually truncate, 1 to 2 mm. long, .5 to 1 mm. wide, short stipitate; fifth gland replaced by a lobe similar to the other lobes but smaller; bracts 5 or more, large, lacerate or entire, hirsute, attached to the side of the involucre below; stamens many; capsule 3 mm. in diameter, slightly wrinkled; pedicel 5 to 8 mm. long; styles .5 mm. long, united at the base, bifid above; stigmas capitate; seeds cylindrical ovoid, flattened at the ends, 2.4 mm. long, 1.8 mm. wide, 1.4 mm. thick, prominently pitted, the pits tending to be circular and in rows; caruncle small, conical, chalazal space large and depressed, raphe prominent. — Mountains of Arizona and adjacent parts of Utah and New Mexico. — Plate 38.

Specimens examined from New Mexico (Wooton, Horse Camp, 350, 1892; Palmer, 57, 1869; Vasey, Santa Magdalena Mts., 23, 1881); Utah (Palmer, St. George, 441, 1877, with long stems covered with small obovate, obtuse leaves; Parry, 1874); Arizona (Palmer, 512, in part, 1876; Newberry, near Leroux Spring, 1858: Anderson, Bill Williams Mt., 1864).

Var. PRINGLEI (Engelm.) n. comb. *E. Pringlei* Engelm. Patterson, Check-list 115. 1887. (name only). *E. montana* Rose, Contr. Nat. Herb. **1**: 125. 1891.

Umbel more branched, the branches spreading; stem leaves oblanceolate spatulate, usually acute, 10 to 25 mm. long, 3 to 6 mm. wide; petioles very short to 2 mm. long; floral leaves rhombic ovate, 8 to 12 mm. wide, 6 to 10 mm.

long, often pubescent; involucres 2 to 3 mm. high; glands larger; styles longer, and more united; capsules 4 to 5 mm. in diameter; seeds larger, some as much as 3.2 mm. long. — Mountains of Arizona. — Plate 39.

Specimens examined (Pringle, Santa Rita Mts., 138 in Engelm. herb., 1881; Palmer, Ft. Huachuca, 455, 1890; Wilcox Ft. Huachuca, ?88, 162, 1894; Rusby San Francisco Mts., 382, 1881; Pringle, 1884; Toumey, Copper Basin, 251a, 1892, pubescent and leaves obtuse, near *E. subpubens*.

E. Palmeri Engelm. in Watson, Bot. California 2:75. 1880.

Many stemmed, 8 to 11 inches high, 3 mm. thick, glaucous, erect; rays 4 to 5, 3 to 5 cm. long, 2 to 3 times branched, a few branches below the umbel; sterile branches from the base small and few; stem leaves oblong obovate, 7 to 17 mm. long, 3 to 10 mm. wide, or the lower ones sometimes smaller, and oblanceolate and acute as on the sterile branches, close together and passing into scales below, 3 to 15 mm. apart above; umbel leaves broadly ovate, shorter and 10 to 15 mm. wide; floral leaves broader to subreniform, apiculate, sometimes slightly erose on the apical margin and sometimes subconnate; involucre whitish, 3 mm. high, slightly narrower, hirsute about the mouth inside, lobes hirsute or ciliate; glands broad ovate, truncate, yellowish brown, punctate, usually short stipitate and turned up at the inner edge; bracts more or less lobed, hirsute above, adnate to the involucre below; stamens about 15; calyx a distinct disc; styles, 1 to 1.5 mm. long, the basal third united, bifid above; stigmas capitate; capsule 5 mm. high, 5.5 mm. wide, cocci rounded, sulci very shallow; seeds ovoid, 2.5 mm. long, 1.5 mm. wide. — Mountains of southern California and extending into Lower California. — Plate 40.

Specimens examined from California (Palmer, Talley's Ranch, Cuyamaca Mts., 450, 1875; Parish, San Bernardino Mts., 444, 1881, 3068, 1894, 3727, 1895, 1880, 1882, near Mexican boundary, 1880, a low form, Long Point, 2457, 1890; Wright, San Bernardino Mts., 1861; Vasey, San Bernardino Mts., 572, 1880; Hasse, San Jacinto Mts., 1892; Orcutt, Smith

Mts., 1882; Cleveland, Laguna, 1885; Parry & Lemmon, 378, 1876); Lower California (Brandegee, San Pedro Martii, 1893; ?Orcutt, Hansen's Ranch, 1883).

Var. PEPLOFOLIA (Engelm.) n. comb. *E. peplofolia* Engelm., in Patterson, Check-list 114. 1887. (name only).

Leaves broader, more rotund; glands small, narrow. — Western Arizona.

Specimens examined (Palmer, Trumbull, 440, Flagstaff, 3970, 1884; Knowlton, San Francisco Mts., 15, 1889; Toumey, San Francisco Mts., 251b, 1892; ? Mearns, San Francisco Mts., 13, 1887, near *E. schizoloba*; Jones, Flagstaff, 3790, 1884).

E. SUBPUBENS Engelm. in Watson, Bot. Calif. **2**: 76. 1880.

Stems several, branching below ground, 1.5 to 2.5 dm. high, a few branches below the much branched umbel, whole plant covered with a fine close pubescence of spreading or crisped short hairs; leaves imbricated when young, obovate rotund, emarginate, sessile or short petioled above, spreading, 3 to 10 mm. long, 2 to 10 mm. wide; umbel leaves irregularly rotund, veins prominent below, floral leaves broad cordate reniform, 10 to 12 mm. wide, 8 to 9 mm. long; involucres 3 to 4 mm. long and wide, whitish, pubescent inside; lobes ovate triangular or truncate, dentate or divided at the apex, ciliate; glands broadly fan-shaped, with many teeth along the margin, dark colored when young, subpeltate, turned upward at the inner edge, 2 to 2.5 mm. wide, 2 mm. long, the fifth gland replaced by one or two small lobes; bracts large, pubescent, lobed or divided, sometimes glandular at the apex; stamens 15 to 20; styles 1 mm. long, united at the base, deeply bifid above; perfect capsules and seeds not seen. — Between *E. Palmeri* and *E. schizoloba*. Central Arizona. — Plate 41.

Specimens examined (Palmer, Prescott, 512 in part, 1876, near *E. Palmeri*; Pringle, Santa Catalina Mts., 1882; Rusby, Flagstaff and Lynx Creek, 1883.

= = Stem leaves elliptical lanceolate, smooth or pubescent; stems slender and often sinuous.

E. SCHIZOLOBA Engelm. Proc. Am. Acad. **5**: 173. 1861; Boiss. DC. Prod. **15²**: 148. 1862. *E. incisa* Engelm. Ives, Rept. on Colorado River of the West **4**: 27. 1861; Watson, Bot. Calif. **2**: 75. 1880.

Stems slender, ascending or erect, sometimes sinuous, 1.5 to 3.5 dm. high, many branches at the base, glaucous green, sterile or fertile branches below the umbel occasional; umbel 3 or sometimes 4-rayed; rays 1.5 to 2.5 cm. long, 2 to 3 times dichotomously branched; stem leaves broad oblanceolate below to ovate above, with petioles 1 to 3 mm. long, entire, smooth or pubescent with short hairs, spreading, 4 to 9 mm. wide, 10 to 14 mm. long; umbel leaves wider, ovate to broad subcordate, or the base truncate; floral leaves broad ovate, mucronate, the base truncate, pubescent above or only at the base, 6 to 10 mm. wide, 4 to 8 mm. long; involucres large, whitish, 3 or more mm. high, 2 mm. wide, almost smooth to very pubescent inside; lobes .5 to 1 mm. long, lobed, dentate and often glandular at the apex; glands semicircular, truncate, irregularly dentate or short horned, stipitate, 1.5 to 2 mm. wide, over 1 mm. long, in dried plants dark brown when young, brownish yellow when older; bracts slender, entire or divided at the apex, usually attached to the involucre at the base; stamens many; capsule oblong ovoid, cocci rotund, sulci deep, 4 mm. wide, 5 mm. high; styles 1 mm. long, short bifid at apex, almost free at base, short clavate stigmatose, seeds oblong cylindrical, irregularly shallow pitted, 2 to 2.5 mm. long, 1.5 mm. wide; caruncle small, conical, one-half as broad as the seed. — Desert regions of southeast California and Arizona. — Plate 42.

Specimens examined from California (Jones, Panamint Cañon, 1897; Coville & Funston, Panamint Mts., 629, 1891, low and much branched); Arizona (Jones, Hackberry, 4728, 1884; Newberry, Railroad Pass, Long Valley, 1899; Smart, Massatzal Mts., 160, 1867).

Var. MOLLIS (Engelm.) n. comb. *E. mollis* Engelm. (name only) in Patterson, Check-list 114. 1887. (not Gmelin).

Whole plant very pubescent with short, spreading hairs; leaves larger, and those of the inflorescence more tapering toward the base. — Arizona. — Plate 43.

Specimens examined (Pringle, 20, 132, 1881, Santa Catalina Mts.; Toumey, Huachuca Mts., 1894; Prim, 1892, Sabine Cañon, 1892; Palmer, Cottonwood Creek, 511, 1876; Lemmon, Santa Catalina Mts., 1880, Rucker Valley, 1881).

↔ ↔ Glands smaller, crescent shaped, bicornute, usually only slightly toothed between the horns; lobes triangular, rarely truncate; bracts mostly small and filiform; seeds with more rotund shallow pits.

E. MONTANA Engelm. Mex. Bound. **2**[1]: 192. 1859; Boiss. DC. Prod. **15**[2]: 148. 1862; Coulter, Bot. West. Tex. 394. 1894. *E. montana gracilior* Engelm. l. c. (in part). *E. Fendleri* Kl. & Gar. Abhandl. Königl. Akad. Berl. **1859**: 85. 1860.

Stems few, slender, 1.5 to 3.5 dm. high, slightly woody below, a few branches at the base and below the umbel; rays 3, 1.5 to 3.5 cm. long, 4 or more times branched; stem leaves rotund to oblong or lanceolate, acute or obtuse, short petioled, spreading or deflexed, 5 to 20 mm. long, 3 to 7 mm. wide; umbel leaves broader, ovate or even cordate; floral leaves broad ovate or cordate, sometimes subpandurate, 8 to 11 mm. wide, 7 to 9 mm. long, glabrous or pubescent; involucres 2 mm. high, turbinate to subglobose, a few hairs on the inside; lobes entire or dentate, pubescent; glands short bicornute, .5 mm. long, 1 mm. wide, short stipitate; bracts short, filiform, almost smooth; capsule depressed ovoid, 3 mm. high, 3.5 mm. wide; styles 1 mm. long, united at the base, short bifid at the apex; stigmas short clavate; seeds ovoid oblong, 2 mm. long, 1.4 mm. wide, ash-colored, deeply and somewhat irregularly pitted; raphe, caruncular space and chalaza sunken; caruncle large, conical, stipitate. — Southern Utah and Colorado and south into Mexico, in the mountains. — Plate 44.

A very variable species, connecting with *E. robusta* by the forms nearest the type specimen (Fendler, 786), and by the variety with *E. odontadenia* and *E. schizoloba;* also by the Texan forms of that species with *E. brachycera*. *E. brachycera* and *E. odontadenia* are scarcely more than subspecies of this.

Specimens examined from New Mexico (Fendler, Santa Fé Creek, 786, 1847; Bigelow, near El Paso, 1282a; Wooton, White Mts., 614, 1897, very slender and tall); Arizona (Pringle, Huachuca Mts., 1889, pubescent, near *E. odontadenia*); Texas (Nealley, Limpia Cañon, 613 = 446, 1889); Mexico (? Mearns, San Luis Mts., 155, 1892).

Var. TRIFARIS n. var.

Stems few to very many, low, 1 to 2.5 dm. high, more slender and sinuous, usually pubescent throughout, little branched; leaves broader, more triangular ovate; involucre as in *E. odontadenia;* seeds and capsule not seen. — Range of the species. — Plate 45.

Specimens examined (Thurber, El Paso, Texas, 160, 1851; Bishop, S. Utah, 1872-4; Eastwood, Navajo Cañon, 1892, pubescent, close to Fendler, 786).

E. ODONTADENIA Boiss. DC. Prod. 15^2: 148. 1862. *E. montana* Engelm. Mex. Bound. 2^1: 192. 1859. (in part).

Stems many, slender and sinuous, 1.5 to 2 dm. high; rays 3 or sometimes 2 or the stem terminated by a single involucre; rays with few branches; stem leaves numerous, oblanceolate to ovate lanceolate, acute, short petioled, 7 to 15 mm. long, 2 to 5 mm. wide; umbel leaves broad ovate, acuminate or acute; floral leaves rhombic circular, 4 to 5 mm. in diameter; involucres broad turbinate, pubescent, 2 mm. high, 2.5 mm. wide; glands ascending, triangular semilunate, dentate between the diverging horns, 1 mm. wide, .7 mm. long; bracts small; seeds oblong, with a prominent, conical caruncle almost half as long as the seed; otherwise as in *E. montana*. — Mountains near El Paso, Tex. — Plate 45.

Specimens examined (Wright, El Paso, 1825, 1851-2; Wright, 661, 1849, Tex.?).

E. BRACHYCERA Engelm. Mex. Bound. 2^1 : 192. 1859; Boiss. DC. Prod. 15^2 : 147. 1862. *E. chamaesula* Coulter, Contr. Nat. Herb. 1 : 48. 1890. *E. campestris* Coulter, l. c.; Heller, Bot. Expl. South. Tex. 60. 1895.

Stems few, 2 to 3.5 dm. high, woody below, leaf scars not prominent, a few branches below the umbel; rays 3 or sometimes 5, 15 to 20 mm. long, many times dichotomous; stem leaves oblong linear, acute or obtuse, sessile or short petioled, 8 to 15 mm. long, 2 to 3 mm. wide; umbel leaves ovate to lanceolate, 4 to 10 mm. wide; floral leaves rhombic or triangular ovate, broadly cuneate to subcordate at base, obtuse, mucronate, 5 to 8 mm. in diameter; involucre 1.5 to 2 mm. high, 1 mm. wide, or more, hirsute inside and on the lobes; glands triangular ovate, crenulate between the short horns; capsule 3.5 to 4 mm. long and wide, depressed ovoid; cocci rounded; sulci shallow; seeds ovoid oblong, covered with rather large, distinct pits, ash colored, darker in the pits, 1.8 to 2 mm. long, 1.3 to 1.4 mm. wide; caruncle large, broad conical, nearly one-half as long as the seed. — Eastern New Mexico and western Texas and in Mexico. The Texas specimens are close to *E. chamaesula* and *E. montana*. — Plate 46.

Specimens examined from New Mexico (Wright, Doñana, 1821, 1851–2); Texas (Nealley, Chanates Mts., 575 = 441, 1889, pubescent, Limpia Cañon, 614 = 440, 1889; Reverchon, Upper Llano, 1593, 140, 1885; Heller, Kerrville, 1599, 1894); Mexico (Pringle, Potrero Peak, Chihuahua, 1143, 1886).

E. CHAMAESULA Boiss. Cent. Euph. 38. 1860; Boiss. DC. Prod. 15^2 : 162. 1862. *E. esulaeformis* Engelm. Mex. Bound. 2^1 : 192. 1859. *E. campestris esulaeformis* Boiss. DC. Prod. 15^2 : 147. 1862. (in part). *E. campestris* Engelm. Euph. Wheeler Exped. 248. 1878.

Stems one to several, 4 to 5 dm. high, rather thick, leaf scars not prominent on the woody base, glaucous, smooth, a number of fruiting or barren branches above the middle of the stem; umbel 3 to 6-rayed; rays 4 to 5 cm. long, 3 or 4 times branched; stem leaves spreading,

short elliptical below to oblong above, smooth, obtuse or occasionally acute, somewhat fleshy, mucronate, erose denticulate, especially above, or entire, 4 to 6 mm. wide, 8 to 20 mm. long, very short petioled, those on sterile branches crowded, oblong linear, more blunt at apex; umbel leaves ovate lanceolate, cordate, 10 mm. wide, 20 mm. long, or less, reflexed or spreading; floral leaves broadly ovate, usually cordate, subpandurate, mucronate, sometimes slightly pubescent, 9 to 13 mm. wide, 11 to 14 mm. long; involucre 3 mm. high, 2 to 3 mm. wide, hirsute inside on the lobes and below the glands; lobes obtuse or truncate; glands short stipitate, yellowish brown, semicircular, with horns of varying length usually incurved, often long dentate between; bracts broader than in related species, lacerate; stamens large and numerous, anthers conspicuous at time of flowering; capsule depressed ovoid, subcordate at base, distinctly narrowed below the apex, 5 mm. long, 6 mm. wide; sulci broad and obtuse; styles 1.5 to 2 mm. long, united about half their length, stigmas large, clavate, recurved more than usual; seeds oblong conical, truncate at both ends, the base very broad and flat, greenish gray to dark brown, covered with large very shallow pits to almost smooth, 2.6 to 3.5 mm. long, 2.2 to 2.8 mm. wide; caruncle conical.— Southern Arizona and New Mexico and northern Mexico. — Often proliferous or producing foliage shoots from the umbel. — Plate 47.

Specimens examined from New Mexico (Wright, Copper Mines, 1820, 1851, a small piece in Dr. Millspaugh's herbarium from Boissier's herbarium, is certainly the same as the specimens of this number in American herbaria, the seeds are not quite smooth; Greene, Silver City, 123, 1880; Rusby, Bear Mts., 381, 1881); Arizona (Toumey, Chiricahua Mts., 6, 1894; Wilcox, Ft. Huachuca, 1891, 1893; Wheeler, 1871–72, or from Nevada?; Toumey, Flagstaff, 252, 1892; Nealley, Rincon Mts., 141, 1891; Palmer, Bill Williams Mt., 1869; Rothrock, Willow Springs, 213, 1874; Lemmon, Huachuca Mts., 1882, a slender form; Pringle, Huachuca Mts., 1884, Santa Rita Mts., 1881, some of the specimens are pubescent, slender, and smaller seeded; Rusby, Mogollon Mts., 378, 1881; Buckminster, approaching *E. campestris*); Mexico (Hartman, 762, 1891; Smith, San Luis Mts.).

Var. SUBDENTATA (Engelm.) n. comb. *E. esulaeformis subdentata* Engelm. Mex. Bound. **2**[1]: 192. 1859.

Leaves, especially the upper, prominently dentate or serrate. — Northern Mexico, and may be found in Arizona. — Plate 47.

Specimens examined (Hartman, San Diego, Chihuahua, 669, 1891; Smith, San Luis Mts.; Parry, San Francisco Spring, 1852.

E. CAMPESTRIS Cham. & Schlecht. Linnaea **5**: 84. 1830; Boiss. DC. Prod. **15**[2]: 146. 1862. *E. esulaeformis* Schauer, Linnaea **20**: 729. 1847. *Tithymalus esulaeformis* Kl. & Gar. Tricoc. 84. 1860. *T. campester* Kl. & Gar. l. c. 86. — Millspaugh, Bot. Gaz. **25**: 25. 1898. *f.*

Stems woody, branching in the lower part, 2 to 4 dm. high, rather slender and wiry, glaucous, reddish, the lower part covered with the prominent leaf scars; umbel 5-rayed; rays 1 to 1.5 cm. long, several times short dichotomous; leaves crowded, usually ascending, linear to oblanceolate, acute, mucronate, entire, some subpetioled, those on the sterile branches smaller and narrower; umbel leaves obovate to ovate, acute; floral leaves nearly rotund to ovate lanceolate, or sometimes obovate, mucronate, subconnate, 3 to 6 mm. wide, 4 to 10 mm. long; involucres 1 to 2.5 mm. wide, 2 to 3 mm. high, hirsute inside; lobes oblong triangular, acute or bidentate, erect or slightly incurved, hirsute; glands semilunar, entire or slightly toothed between the short often incurved horns, .5 to .8 mm. long, .8 to 1.5 mm. broad, the horns about as long; bracts attached to the involucre below, linear lanceolate, hirsute all over; pedicels of staminate flowers pubescent; capsule ovoid globose, slightly depressed, smooth, 3.5 mm. wide, 3 mm. high; cocci rounded, with a prominent line on the back; sulci shallow, obtuse; pedicel 5 mm. long; styles 1 mm. long, more or less united above the base, short bifid, stigmas clavate thickened; seeds ellipsoid, subangular in cross section, slightly flattened, covered with

broad irregular flat ridges or broad shallow pits, gray, the ridges usually white, 2.2 to 2.4 mm. long, 1.2 to 1.7 mm. wide, raphe sunken, a rather acute ridge on the back; chalazal space deep; caruncle depressed conical. — Eastern, central, and southern Mexico. The two specimens from Texas referred here are too near *E. brachycera*. — Plate 48.

Specimens examined from Mexico (Gregg, San Antonio, 351, 1848–49, Saltillo, 426, 1848–9, Real del Monte, 643, 1849; Palmer, Durango, 72, 1896, Coahuila, 1226-27–28, 1880, Saltillo, 1225, 2054, 1880; Parry & Palmer, San Luis Potosi, 803, 1878; Halm, 1868; Ghiesbreght, Chiapas, 734, 1864–70, a form; Hartweg, 31, 1857; Ascherborn, from the type of *E. esulaeformis;* Halstead, Volcan. de Pizzaro; Schiede, 38; Seaton, Mt. Orizaba, 224, 1891; J. D. Smith, Guatemala, 3476, 1892; Nelson, Oaxaca, 1361, 1894; Duges, Guanajuata, 1880, 1883; Graham, Herb. J. S. Mill; Schaffner, Vallée de Mexico, 1875, San Luis Potosi, 1864, 1866, 1876); Texas (Wright, Nueces, 1404, Rio Grande, 1848).

E. ROBUSTA (Engelm.) Small in Brit. & Brown, Ill. Flora **2**: 381. 1897. *E. montana robusta* Engelm. Mex. Bound. **2**[1]: 192. 1859. *E. montana* Boiss. DC. Prod. **15**[2]: 148. 1862. (in part); Coulter, Man. 327. 1885; and most authors. — Brit. & Brown, Ill. Flora. *f. 2338.*

Stems many, stout, 1 to 3 dm. high, covered at the base below ground with broad ovate membranaceous scales, many large spreading branches below the 3 to 5-rayed umbel, smooth or occasionally pubescent especially at the base of the floral leaves; rays short, many times dichotomous; sterile branches with smaller and narrow lanceolate oblong leaves usually present; stem leaves oblong to ovate cordate, usually sessile, 10 mm. wide, 12 mm. long; floral leaves broadly ovate to cordate, 10 to 15 mm. wide, 10 to 12 mm. long; involucres 2.5 mm. high, 1.5 mm. wide, hirsute inside; lobes triangular or lanceolate triangular, hirsute, sometimes bidentate at the apex; glands semilunate, short horned and sometimes dentate between the horns, 1 to 2 mm. wide, 1 mm. or less long; fifth gland replaced by a lobe shorter than the other lobes; bracts short, narrow, pubescent; stamens several, their pedicels

sometimes pubescent; capsule depressed ovoid, smooth, deeply sulcate, 4 to 4.5 mm. wide and high; pedicel 4 to 5 mm. long or longer; styles united below, deeply bifid; stigmas clavate; seeds ovoid, somewhat flattened at the lower end, covered with very shallow, circular, or irregular pits, sometimes almost smooth, usually white, 2.3 mm. long, 1.6 mm. wide, caruncle low conical. — In the Eastern Rocky Mountains, Colorado to Montana. Northward the plants are more dense, more scaly at the base and the leaves broader. Southward they are more slender, less branched, and the leaves narrow elliptical ovate, connecting with *E. montana*. — Plate 49.

Specimens examined from Colorado (? James, Long's Exped.; Vasey, 518, 1868; Parry, 438, 1862; Hall & Harbour, 509, 1862; Trelease, Ute Pass, Georgetown, 1886; Gurney, 1890; Mulford, Colorado Springs, 1892; Redfield, Colorado Springs, 7411, 1872; Parry, Clear Creek, 436, 1862, seeds nearly smooth; Engelmann, Idaho, 1874, Empire City, 1881; Jones, Colorado Springs, 32, 1878; Northrop, Pike's Peak, 1888; Pammel, Larimer Co.; Eastwood, Steamboat; Baker, Larimer Co., 3.5 dm. high; Snow, 3 dm. high; Wolf, 85, 1873; Patterson, Clear Creek, 132, 1885; Coulter, Denver, 1873, Clear Creek, 1872); Montana (Tweedy, Livingston, 1889; Blankinship, 44, 1890; Ward, Glendive, 1883); Nebraska (Webber, Pine Ridge, 1889; Williams, Pine Ridge, 1890; Rydberg, McColligan Cañon, 362, 1891); South Dakota (Rydberg, Hot Springs, 997, 1892; Forwood, Black Hills, 1887); Wyoming (Nelson, Whalen Cañon, 529, 1894; Hayden, 1860); early northern collections (Mersch, North Platte, 1843; Nuttall; Fremont Exped., 1842).

A pubescent form is represented by Williams, Belt Mts., Montana, 357, 1886; Scribner, mouth of Shield's River, Montana, 250, 1883; Nelson, Pine Creek, Wyoming, 26, 1892; Crandall, Ft. Collins, Col., 1890.

Letterman, Colorado Springs, Col., 229, 1884; Crandall, Ft. Collins, 456, 1895; Schneck, Denver, Col., 1893; Wislizenus, between Placer, Col., and Albuquerque, N. M., 3, 1846; Sheldon, Buena Vista, Col., 579, 1892; Coulter, Denver, Col., 1873; are of the more slender southern form.

Var. INTERIORIS n. var.

Not much branched below the umbel; rays 2.5 to 4

cm. long; leaves large, usually thinner, broader; glands serrate. — West of the Rocky Mountains in Colorado, Utah, and Arizona. — Some specimens approach *E. schizoloba* and *E. Palmeri peplofolia*. — Plate 49.

Specimens examined (Watson, Wahsatch Mts., Utah, 1081, 1869; Eastwood, Mancos, Col., 1891; Johnson, South Utah, 1876; Brandegee, Cañon City, Col., 396; Jones, Cedar City, Utah, 5206, 1894; Palmer, Arizona, 1869. The last three are doubtfully placed here.

+ + Perennial by a horizontal rootstock or by buds from long, horizontal roots; umbel many-rayed; seeds smooth; introduced from Europe.

E. Cyparissias Linn. Sp. Plant. 461. 1753; Boiss. DC. Prod. **15**^{2}: 160. 1862; Gray, Man. 388. 1857. [2d ed.]; Macoun, Cat. 426. 1886; Brit. & Brown, Ill. Flora **2**: 381. 1897. *Tithymalus Cyparissas* Hill, Hort. Kew. 172 (4). 1768; *T. Cyparissias* Lam. Fl. Fr. **3**: 96. 1778. (fide Index Kewensis). *T. angustifolius* Gilib. Fl. Lituan. **2**: 209. 1792. (fide Index Kewensis). *Euphorbia Esula* Tenore, Fl. Nap. **1**: 273. (fide Index Kewensis). *Esula Cyparissias* Haw. Pl. Succ. 155. 1812. *Esula cupressina* S. F. Gray, Nat. Arr. Brit. Pl. **2**: 259. 1821. *Keraselma Cyparissias* Rafin. Fl. Tell. **4**: 116. 1836. (fide Index Kewensis). *Tithymalus acicularis* Dulac, Fl. Hautes-Pyr. 156. 1867. (fide Index Kewensis). *Euphorbion cyparissium* St. Lager, Ann. Soc. Bot. Lyon **7**: 126. 1880. *E. capparis* Hyams, Journ. Elisha Mitchell Soc. **1884–5**: 75. 1885. *Esula pensylvanica* Gandoger, Fl. Eur. **20**: 107. 1890. — Reichenb. Ic. Fl. Germ. *f. 4793;* Brit. & Brown, Ill. Flora *f. 2337;* Pammel, Seedcoats *pl. 12. f. 18c.*

Long horizontal roots covered with adventitious buds; stems several to many, 8 to 13 cm. high, bright green, glaucous, somewhat striate; umbel about 15-rayed; rays 1 to 2 cm. long, slender, 2 to 3 times dichotomous; branches below the umbel mostly sterile, after fruiting time much

elongated beyond the primary umbel; stems covered below with ovate, acute, imbricated scales which pass into crowded, linear, entire, obtuse leaves; middle stem leaves 1 to 3 cm. long, 1.5 to 3 mm. wide, tapering at the base, margins often revolute, some of the upper dilated at the base; leaves of sterile branches narrower, acute; umbel leaves linear lanceolate, shorter, dilated at the base; floral leaves broadly ovate, obtuse, light colored when young, subpandurate, 8 mm. broad, 6 mm. long, nerves prominent; involucres 1.5 mm. high; lobes ovate, rounded truncate, ciliate with short hairs, a few short hairs beneath the glands inside; glands semilunate, with short diverging horns, less than 1 mm. wide, somewhat declined, bright golden brown when dry; the fifth gland replaced by a small, acute lobe; bracts none or very small; stamens several; capsule erect, its pedicel very short, depressed globose, 3.5 mm. wide, 3 mm. high; cocci rounded, with short warts on the back; sulci obtuse; styles .7 to 1 mm. long, united more than half their length, bifid above; stigmas almost capitate, recurved; seeds ellipsoid, very slightly flattened, 1.7 to 1.9 mm. long, 1.3 to 1.4 mm. wide, brownish gray; chalazal depression shallow, circular; raphe a brown colored line; caruncle thin, flat or saddle shaped. — A weed naturalized from Europe in the northeastern United States and lower Canada from Nova Scotia to Delaware, west to northern Michigan and Kansas, one specimen from Colorado. Rarely producing seed in this country. — Plate 50.

Specimens examined from Maine (Redfield, Mt. Desert Island, 16528, 1890; Gayle, Cape Elizabeth, 701, 1895); Massachusetts (Fritchey, Provincetown, 1889; Redfield, Pittsfield, 7369, 1874; Whitfield, Mt. Washington, 1889; Waverly, 1895; Boott, Boston, 1866); Michigan (Trelease); Iowa (Reppert, Muscatine, 127; Arthur, 710, 1875; Rolfs, Boone Co., 1891; Hitchcock, Iowa City; Fink, Fayette Co., 123, 1894); New York (Brown, Staten Island, 1879; Millspaugh, Binghamton, 1882, Broom Co., 1885, Tioga Co.; Curtiss, Oswego, 1866; Kerr, Staten Island, 1895; Trelease, Ithaca, 1878); Colorado (Cowen, Ft. Collins, 452, 1895); Kansas (Manhattan, various collectors, 1890–96); Missouri (Bush, Jackson Co., 1888); Pennsylvania (Small, Lancaster, 1889, 1891; Porter, Easton, 1869; Heller, Lancaster, 1891; Curwen, Warren, 1895); New Jersey (Shuh, Franklin,

1887; New Market, 1892; Stowell, Hammonton, 1891); New Hampshire (Robinson, Jaffrey, 221, 1897); Connecticut (Eaton, New Haven, 1858; Eames, Bridgeport, 1893; Pollard, Green's Farms, 1894); Vermont (Stevens, Lake Willoughby, 1895; Kent, E. Wallingford, 1897; Hinsdale, St. George, 1892; Ruggles, Hartland); Wisconsin (Kellogg, 1888); Ohio (Kellerman, Newport, 1897; Jaske, Dayton, 1895; Wilkinson, 1892); Ontario (Burgess, London, 1891); Kentucky (Kate Palmer, Louisville, 1888).

Also reported from New Brunswick and Nova Scotia (Macoun, Cat. Can. Plants 426).

E. Esula Linn. Sp. Plant. 461. 1753; Gray, Man. 405. 1848; Brit. & Brown, Ill. Flora **2**: 380. 1897; Boiss. DC. Prod. **15**^{2}: 160. 1862. *Tithymalus Esula* Hill, Hort. Kew. 172 (4). 1768; Scop. Fl. Carn. **1**: 338. 1772. [2d ed.]. *T. linifolius* Lam. Fl. Fr. **3**: 95. 1778. (fide Index Kewensis). *Euphorbia tristis* Besser, Index Hort. Crem. Suppl. 4: 27. 1811. (fide Boiss. DC. Prod.). *Esula Dalechampii* Haw. Pl. Suc. 155. 1812. ? *Euphorbia salicifolia* DC. Fl. Fr. **6**: 362. 1815. *E. angustifolia* Sweet, Hort. Brit. 357. 1827. (fide Index Kewensis). ? *E. racemosa* Tsch. in Reichenb. Fl. Germ. Excurs. 761. 1832. *Keraselma Esula* Rafin. Fl. Tell. **4**: 116. 1836. (fide Index Kewensis). *Euphorbia discolor* Ledeb. Fl. Ross. **3**: 577. 1846–51. *E. Fleuroti*, *E. riparia*, *E. Loreyi*, *E. ararica* Jord. Billot. Annot. Fl. Fran. et Allem. 27. 1855. (fide Boiss. in DC. Prod.). *E. intermedia* Bréb. Fl. Normand. 271. 1859. [3d ed.]. *Tithymalus discolor* Kl. & Gar. Tricoc. 97. 1860. *T. tristis* Kl. & Gar. l. c. 92. *Euphorbion Esulum* St. Lag. Ann. Soc. Bot. Lyon **7**: 125. 1880. — Reichenb. Ic. Fl. Germ. *f. 4791;* Brit. & Brown, Ill. Flora *f. 2335;* Pammel, Seed-coats *pl. 12. f. 18b.*

Stems about 4 cm. high, striate, many branches below the 8 or 9-rayed umbel, the lower sterile; rays about 3 times dichotomous, leaves crowded below and more or less scale-like; middle stem leaves 4 to 8 mm. wide, 3 to 6 cm.

long, tapering to the base, but sessile, linear oblong or lance-linear, sometimes oblanceolate, ascending or spreading, smooth, entire, acute, mucronate, with an evident marginal line, those on sterile branches smaller, 2 to 2.5 cm. long, obtuse or acutish; umbel leaves lanceolate, 2 to 3 cm. long; floral leaves broadly ovate, 14 to 16 mm. wide, 10 to 13 mm. long; involucres 1.5 mm. high, 1 mm. wide, lobes ovate, truncate, projecting beyond the glands, erect, a few hairs on the edge and under the glands inside; glands semilunar, dark colored, 1 mm. wide, 5 mm. long, slightly declined, horns short, diverging; bracts one-half as long as the involucre, filiform; stamens many; capsule depressed ovoid, 4.5 to 5 mm. wide, 3.5 mm. high; cocci rounded, roughened on the back with small ridges and papillae; sulci deep, obtuse; styles 2 to 2.5 mm. long, united about one-third of their length, bifid above, recurved, clavate stigmatose; seeds ellipsoid ovoid, circular in cross section, 1.5 mm. in diameter, 2 mm. long; chalazal space shallow; caruncle thin, flat, orbicular. — Naturalized from Europe in a few places in the northeastern United States. — Plate 51.

Specimens examined from Massachusetts (Oakes, Ipswich, Newbury, 1827, Essex Co., 1842); Maine (Parlin, Berwick, 1894); New York (Dudley, Groton, 797, 1895).

Also reported from Niagara and Attica, N. Y. (Day, Fl. Buffalo 67, 1883); Indiana (Schneck, 7th Ann. Rept. Geol. Surv. Ind. 558. 1876); near Lansing, Michigan (Beal, Mich. Flora 129. 1892).

E. LUCIDA Waldst. & Kit. Pl. Rar. Hung. **1**: 54. *pl. 54.* 1802. (fide Boiss. in DC. Prod. **15²**: 163. 1862). *E. pallida* Willd. Sp. Plant. **2**: 923. 1799. *Galarhoeus Androsemifolius* Haw. Pl. Suc. 146. 1812. *Keraselma lucida* Rafin. Fl. Tell. **4**: 116. 1836. (fide Index Kewensis). *Euphorbia androsaemifolia* Steud. Nom. **1**: 610. 1841. [2d ed.]. *Tithymalus lucidus* Kl. & Gar. Tricoc. 89. 1860. *Euphorbia virgata* Noe in Nyman's Conspect. 652. 1881. *E. oleaefolia* Noe, l. c. *E. Nicaeensis* Millspaugh(?), Bull. Torr. Bot.

Club **14**: 24. 1887; Watson, Gray, Man. 456. 1890. [6th ed.]. Millspaugh, Medic. Plants **2**: 150. 1892; Brit. & Brown, Ill. Flora **2**: 380. 1897. — Reichenb. Ic. Flora Germ. *f. 4797;* Millspaugh, *pl. 150.* (distributed in herbaria); Brit. & Brown, Ill. Flora *f. 2336.*

Stems 6 to 12 dm. high, 5 to 10 mm. thick, striate; umbel about 12-rayed; rays 3 to 4.5 cm. long, 2 to 3 times dichotomous; many similar branches below the umbel; leaves crowded below, the lower scale like, those on the middle of the stem oblong lanceolate, smooth, shining, truncate or cordate at base, sessile or short petioled, obtuse or acutish, mucronate, reflexed, 6 to 10 cm. long, 2.5 cm. wide, pinnately veined, margin entire, subrevolute; leaves on sterile branches smaller, 2.5 to 3 cm. long; umbel leaves lanceolate with a cordate base, to cordate; floral leaves broad ovate cordate, mucronate, 15 to 17 mm. wide, 10 to 12 mm. long, yellow at time of flowering; involucres 2.3 mm. high, 2.5 to 3 mm. broad, white membranaceous, pubescent with short hairs beneath the glands inside; lobes oblong, truncate, ciliate, erect; glands transversely ovate, margin truncate or undulate, 1 to 2 mm. wide, 1 mm. long, yellow, horns .5 mm. long; bracts filiform, almost as long as the involucre, a few hairs at the apex; stamens many; capsule ovoid, punctate scabrous; styles 2 mm. long, united one-third of their length, bifid one-third; stigmas clavate, recurved; seeds ovoid oblong, gray; caruncle oblong, flattened. — Introduced from Europe into central New York. *E. Nicaeensis*, with which this has been confused, has short fleshy, trinerved leaves. Like *E. Cyparissias*, it seems, this plant rarely if ever produces seed in this country, but, no doubt, spreads extensively by the long roots or rhizomes. Underground parts, mature capsules and seeds not seen. — Plate 52.

Specimens examined from New York (Millspaugh, Vestal, 1885, 1886, Waverly, 1888; Clute, Vestal, 1896, Binghamton, 1896; Curtice, Moravia); Pennsylvania (Clute, Susquehanna Co., 1896).

E. Paralias Linn., with crowded lanceolate, sessile, fleshy leaves, is said to occur as a ballast plant at Girard Point, Philadelphia, Penn. (Burk, Proc. Acad. Sci. Phil. 1877: 108).

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EXPLANATION OF PLATES.

The habit drawings, except in plates 48, 51 and 52, drawn by the author, were made from herbarium specimens by Mrs. Grace Johnson Vieh under the supervision of the author. The details were drawn by the author, in most cases with a camera lucida, and will show the most important characters of each species. Unless otherwise indicated the details are enlarged five diameters, except those of the seeds, which are enlarged eight diameters. The habit drawings are reduced one-half.

Plate 11, *E. Lathyris*.— 1, Involucre, glands, and staminate pedicels and bracts; 2, ventral view of seed; 3, lateral view of caruncle.

Plate 12, *E. Floridana*. Staminate and pistillate plants. — 1, Portion of involucre; 2, group of stamens and bract; 3, lobe and bract; 4, rudimentary staminate and pistillate flowers; 5, young pistillate flower; 6, cocci; 7, 8, seeds.

Plate 13, *E. inundata*. Staminate and pistillate plants. — 1, 2, Involucres and glands; 3, staminate flowers and bract; 4, lobe, × 5, margin of lobe and bract, much enlarged; 5, portion of capsule; 6, seeds.

Plate 14, *E. telephoides*. — 1, Portion of involucre and glands; 2, involucre with young capsule.

Plate 15, *E. Darlingtonii*. — 1, Hairs from leaf, much enlarged; 2, involucre, lobe, and gland; 3, staminate flower and bracts; 4, 5, seeds.

Plate 16, *E. platyphylla*. — 1, Involucre and gland; 2, lobe and bract, much enlarged; 3, staminate flower and bract; 4, old involucre with capsule; 5, capsule; 6, seeds.

Plate 17, *E. obtusata*.— 1, Involucre, staminate flower and bract; 2, lobes and sinus, much enlarged; 3, involucre; 4, capsule and styles; 5, seeds.

Plate 18, *E. Arkansana*. — 1, Leaves; 2, involucre; 3, 4, lobes and bracts, much enlarged; 5, involucre and capsules; 6, capsule, staminate pedicel, and bract; 7, seed. Var. *Missouriensis*.— 8, Upper part of plant; 9, leaves and seed.

Plate 19, *E. Arkansana*.— 1, Southern Texas form (Heller, 1475); 2–6, var. *Coloradensis*. — 2, plant; 3, 4, leaves and capsule from Watson, Antelope Island, Utah; 5, 6, leaf and capsule from Vasey, Colorado, 1868.

Plate 20, *E. Arkansana atrosemina*. — 1, Floral leaf; 2, lobes, sinus, and gland, much enlarged; 3, bract, much enlarged, and capsule; 4, seeds.

Plate 21, *E. Mexicana*.— 1, Leaves; 2, involucre; 3, bract, glands, and lobes, much enlarged; 4, capsules; 5, seeds.

Plate 22, *E. dictyosperma*. — 1, Leaves; 2, involucres, staminate flower and bract; 3, bracts, much enlarged; 4, lobes and sinus, much enlarged; 5, capsules; 6, seed.

Plate 23, *E. dictyosperma*. — 1, Robust form, old plant (Brewer, 1214); 2, involucre, capsule, and seed of same; 3, bracts of same, much enlarged; 4, slender form (Hort. Cantab. 1856); 5, leaf and seed of same; 6, lobe of same, much enlarged; 7, seed of Lower Californian plant.

Plate 24, *E. alta*. — 1, Involucres; 2, involucre and staminate pedicel and bract; 3, capsule; 4, branched wart of capsule, and styles; 5, seeds.

Plate 25, *E. leiococca*. — 1, Leaves; 2, involucres, staminate pedicel and bract; 3, portion of involucre, much enlarged; 4, capsules; 5, seeds.

Plate 26, *E. Helioscopia*. — 1, Leaf; 2, involucres, staminate pedicel and bract, and gland; 3, bract, much enlarged, and hair from same, still more enlarged; 4, capsule; 5, seeds.

Plate 27, *E. trichotoma*. — 1, Leaf; 2, involucre, lobe, and staminate pedicel with bracts; 3, bracts, much enlarged; 4, capsule; 5, seeds.

Plate 28, ***E. exigua.*** **— 1, Stem leaf; 2, base of floral leaves; 3, involucre, staminate pedicel and bract, gland and lobes; 4, capsules; 5, seeds.**

Plate 29, ***E. Helleri.*** **— 1, Leaves; 2, portion of involucre, gland, and bract; 3, gland, somewhat enlarged, bract and lobe, much enlarged; 4, capsule; 5, seeds.**

Plate 30, ***E. Peplus.*** **— 1, Involucre, staminate pedicel and bract, and glands; 2, capsule; 3, seeds.**

Plate 31, ***E. peplidion.*** **— 1, Leaves; 2, involucre, staminate pedicel and bract, and glands; 3, old involucre; 4, capsule; 5, seeds.**

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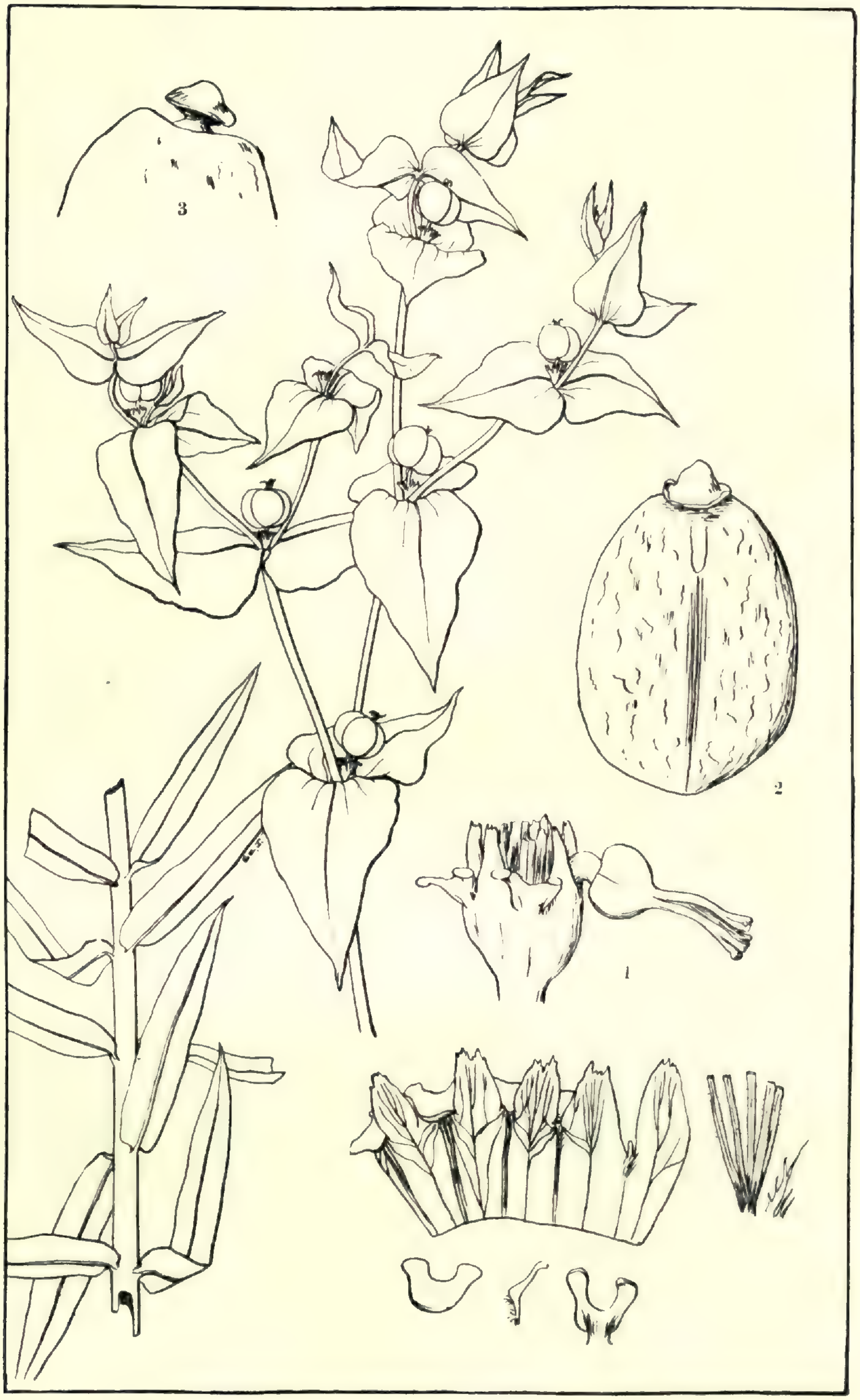

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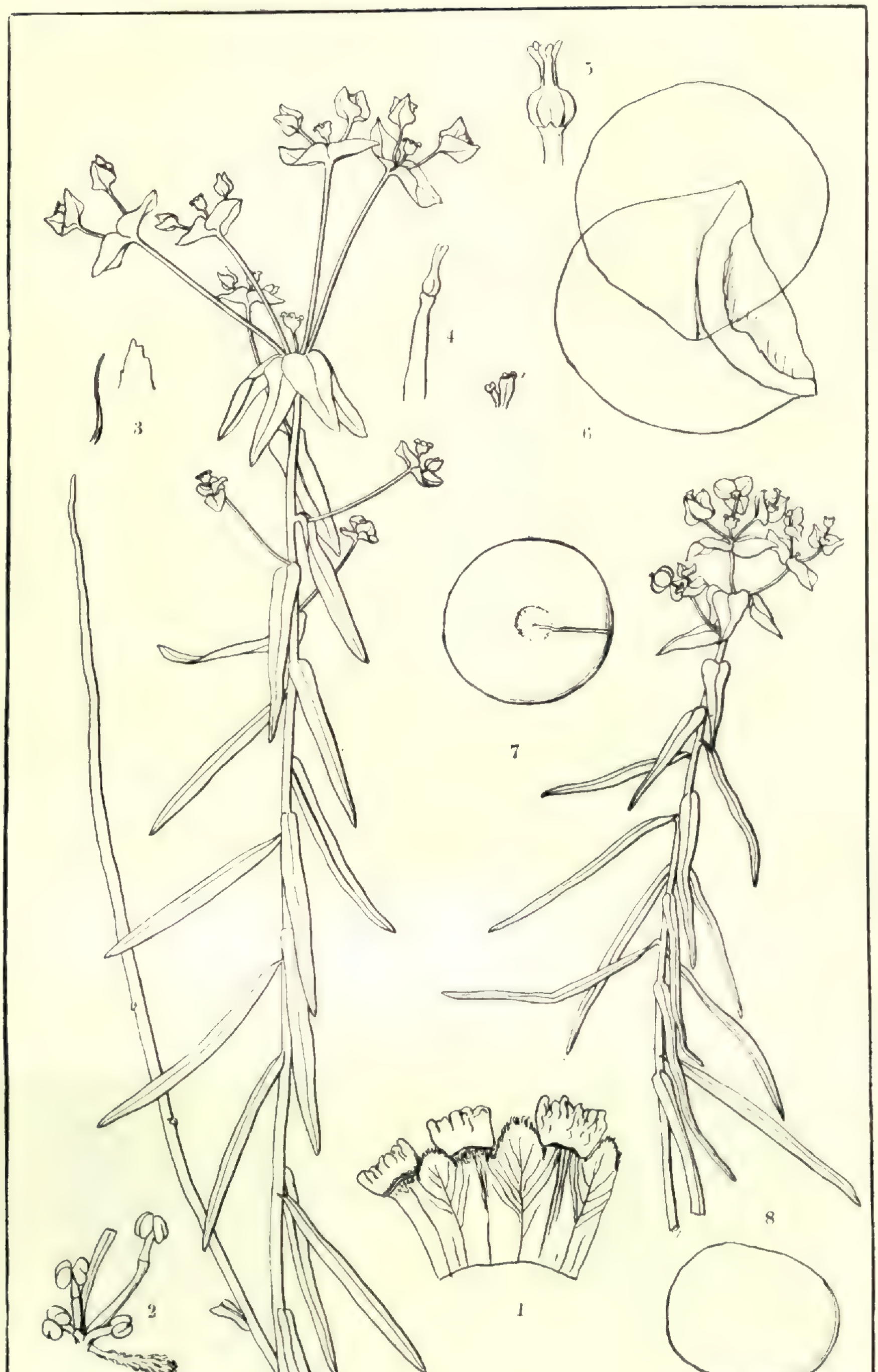

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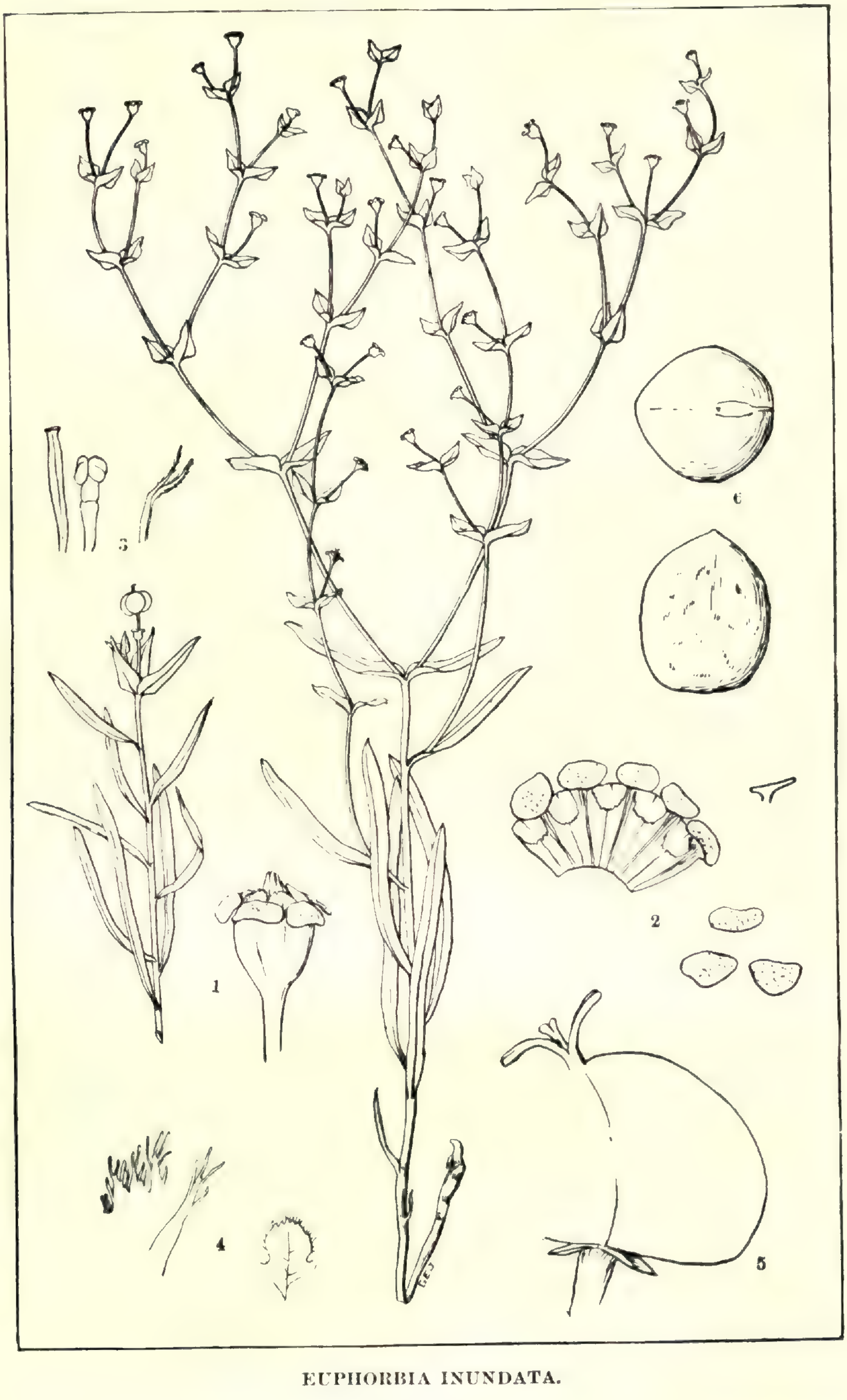

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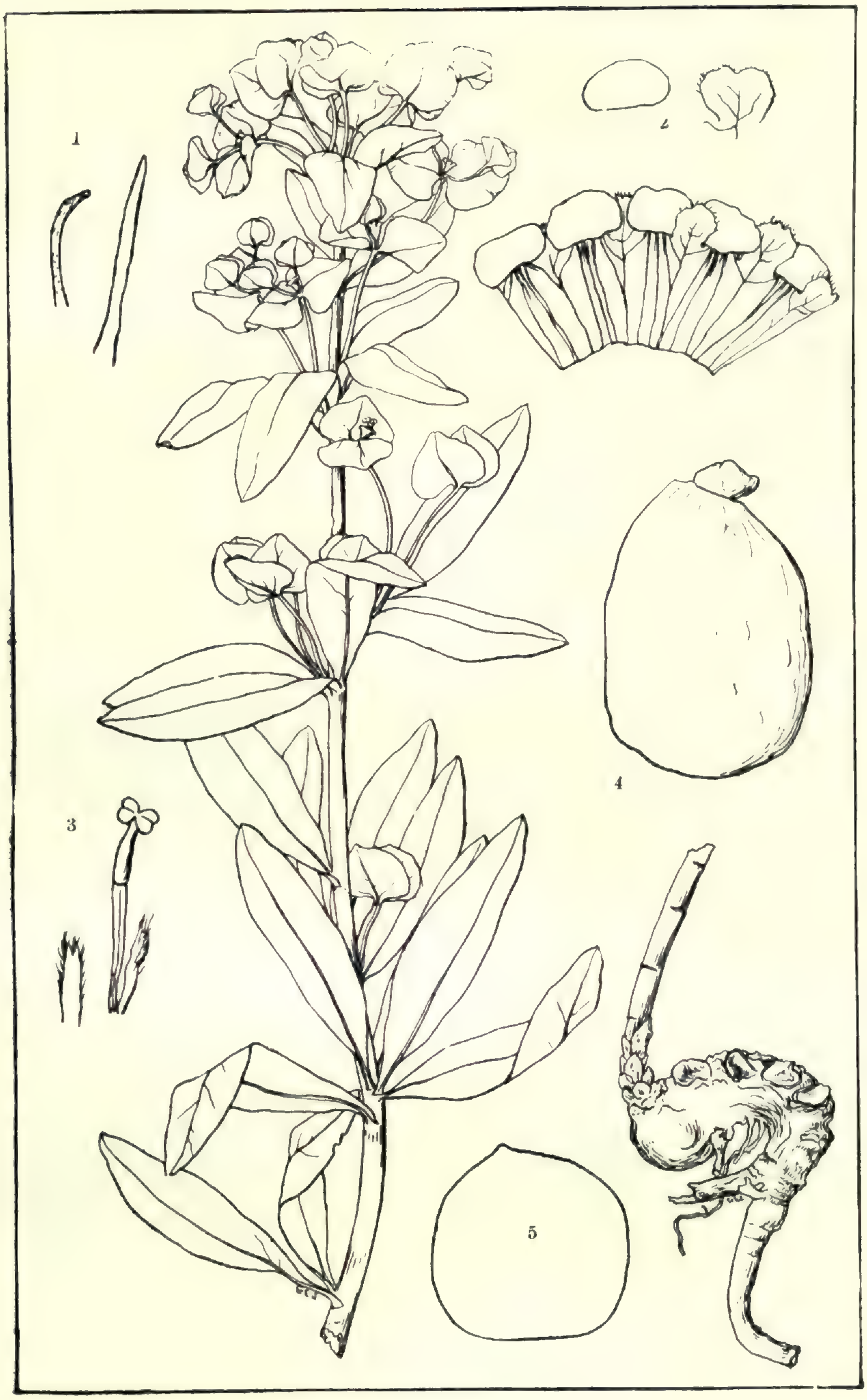

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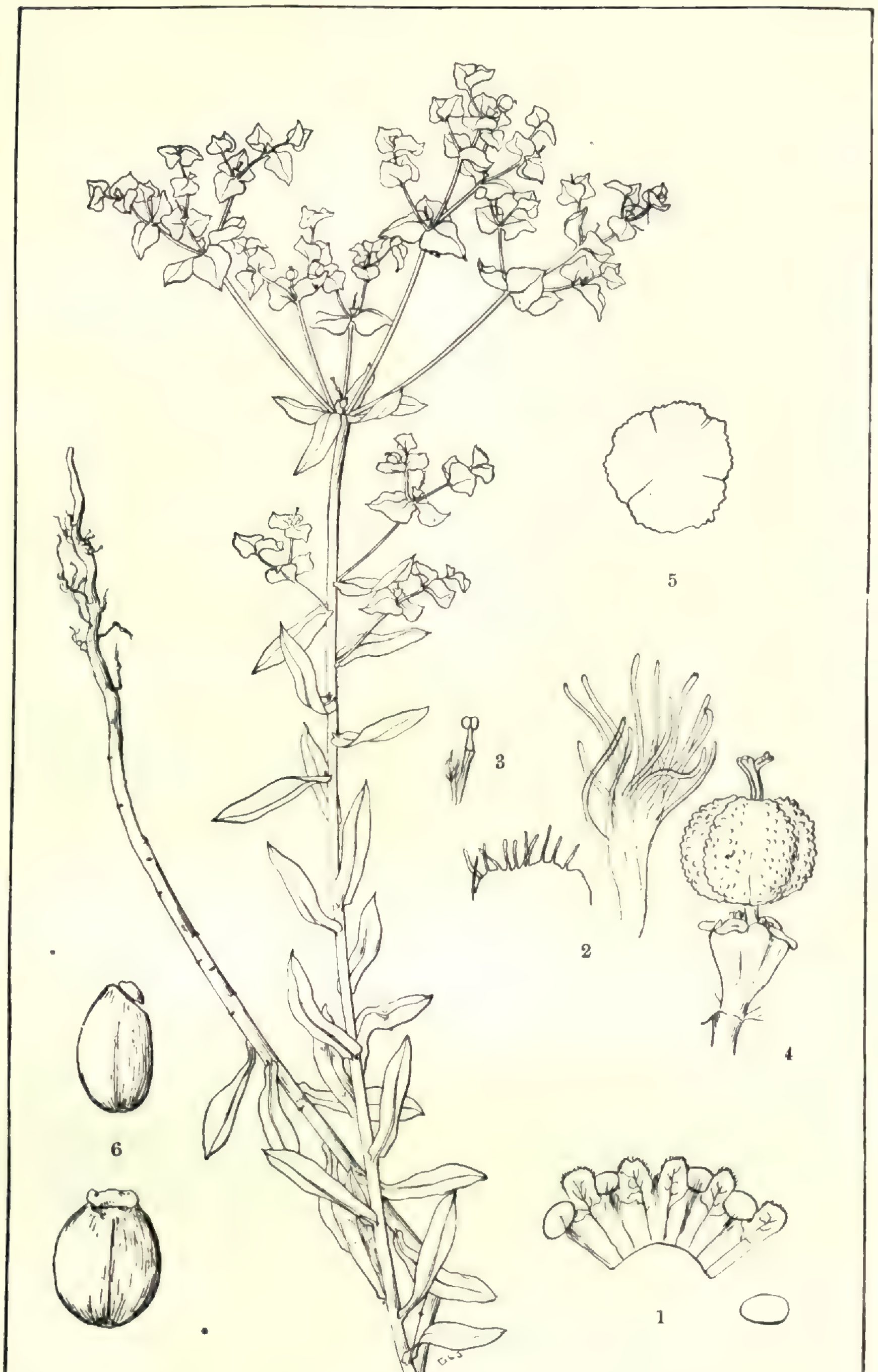

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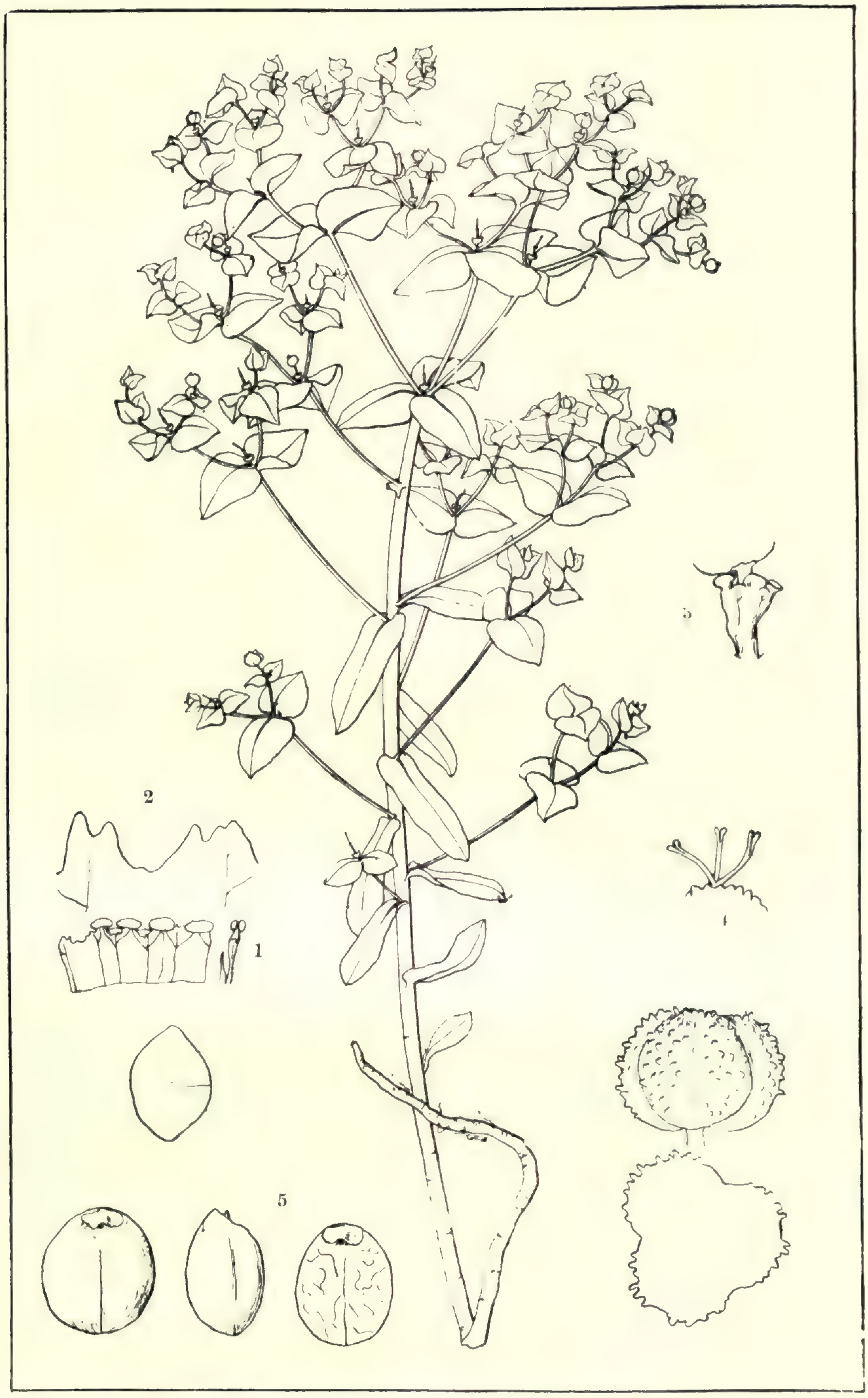

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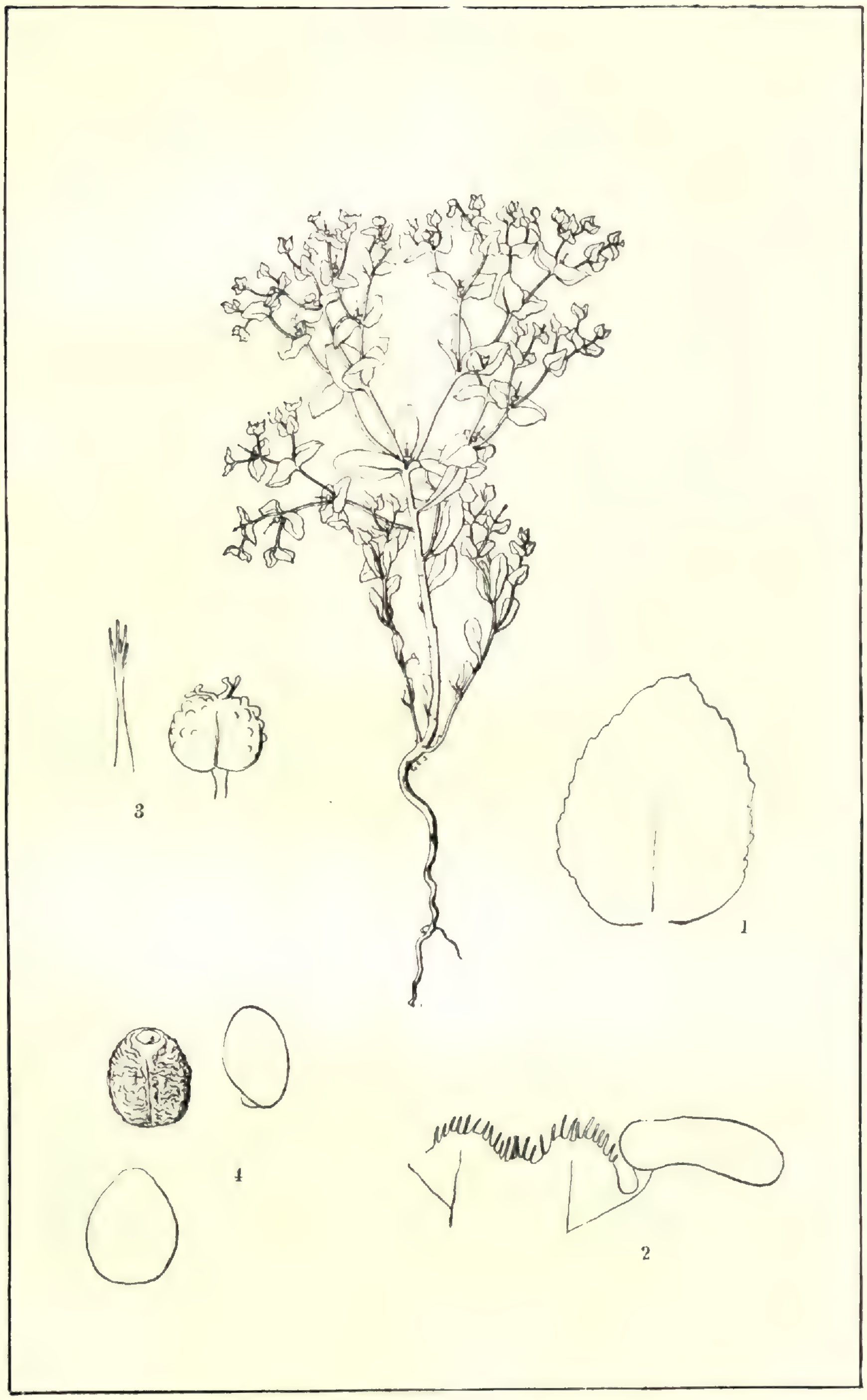

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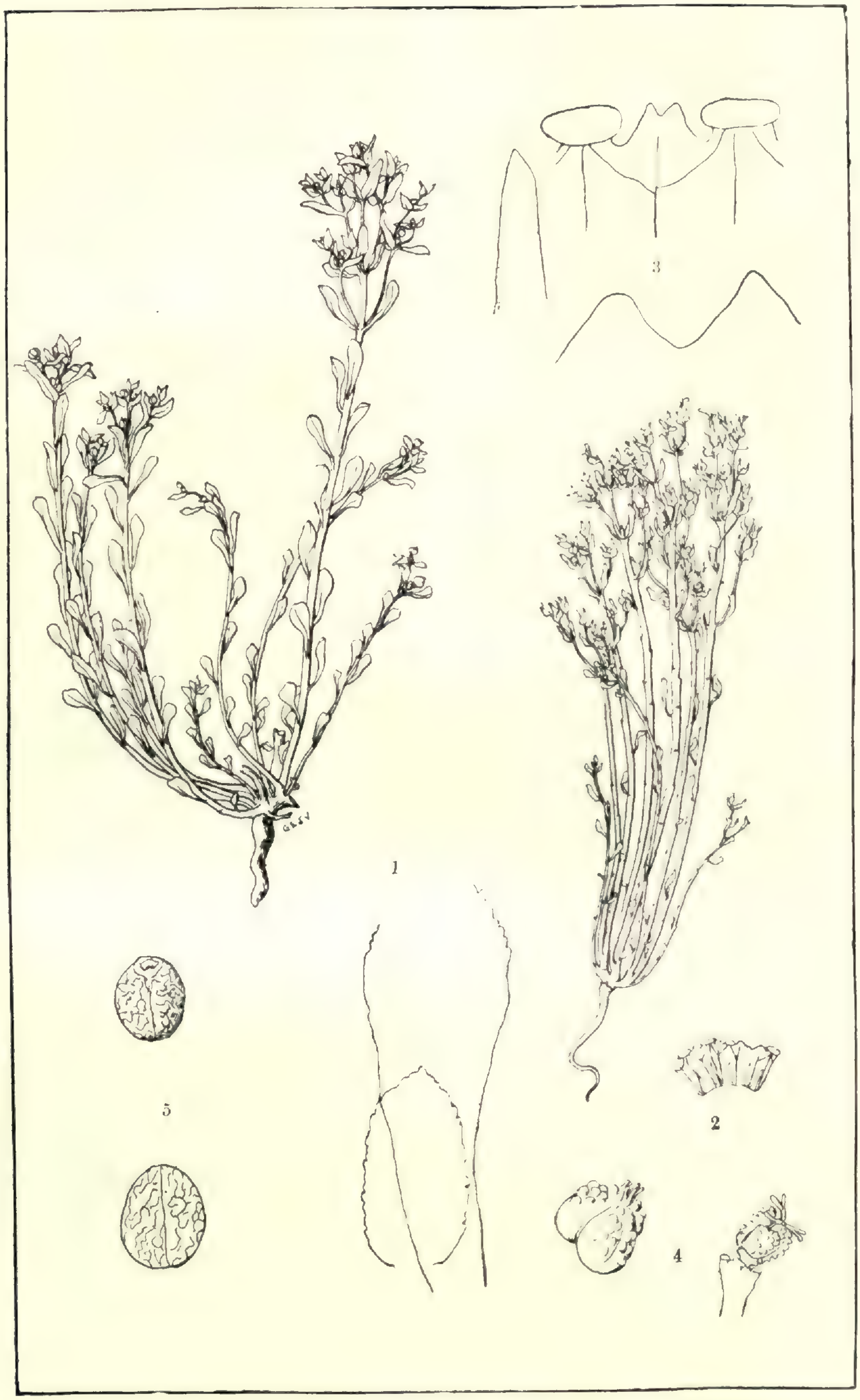

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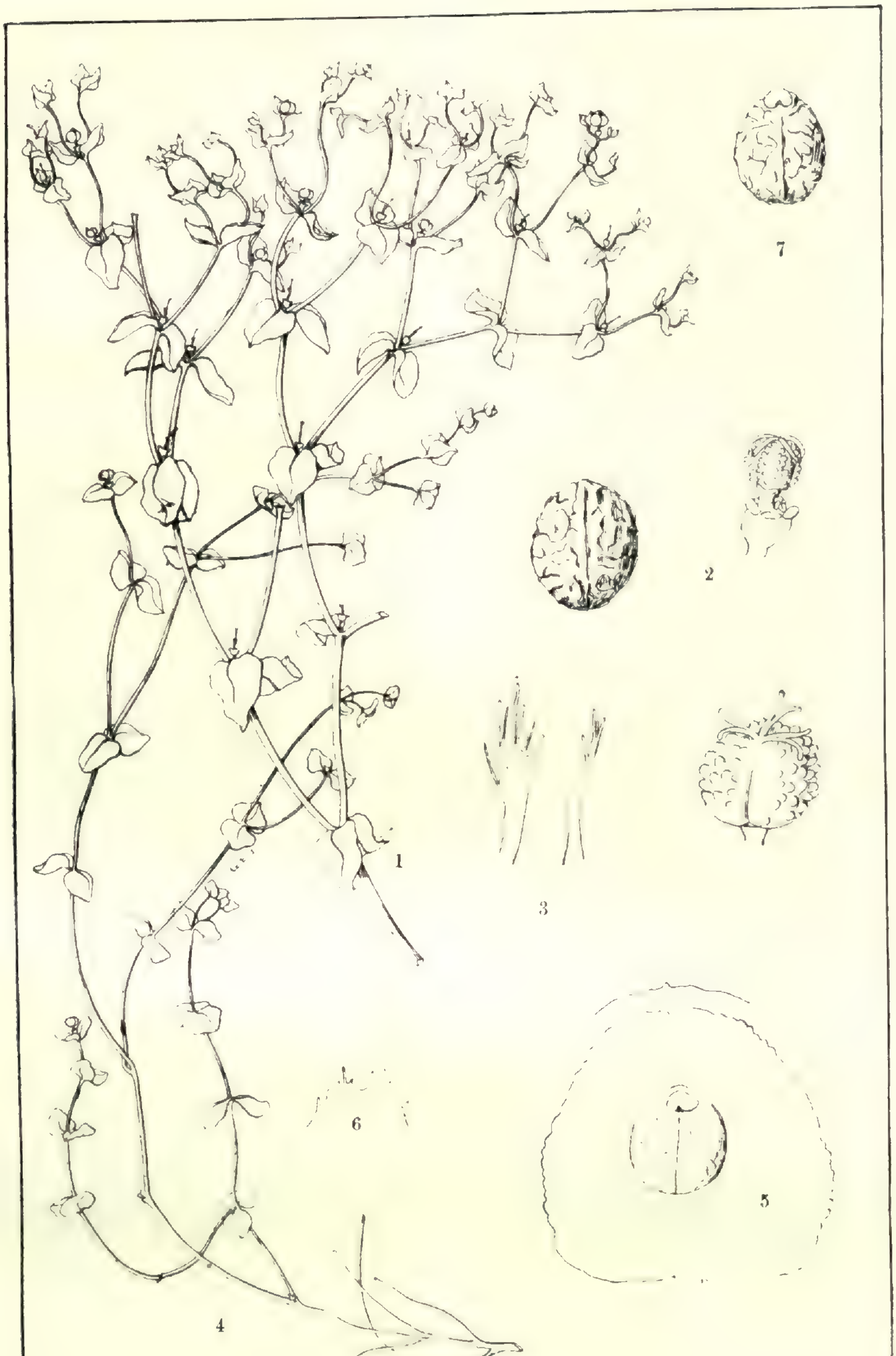

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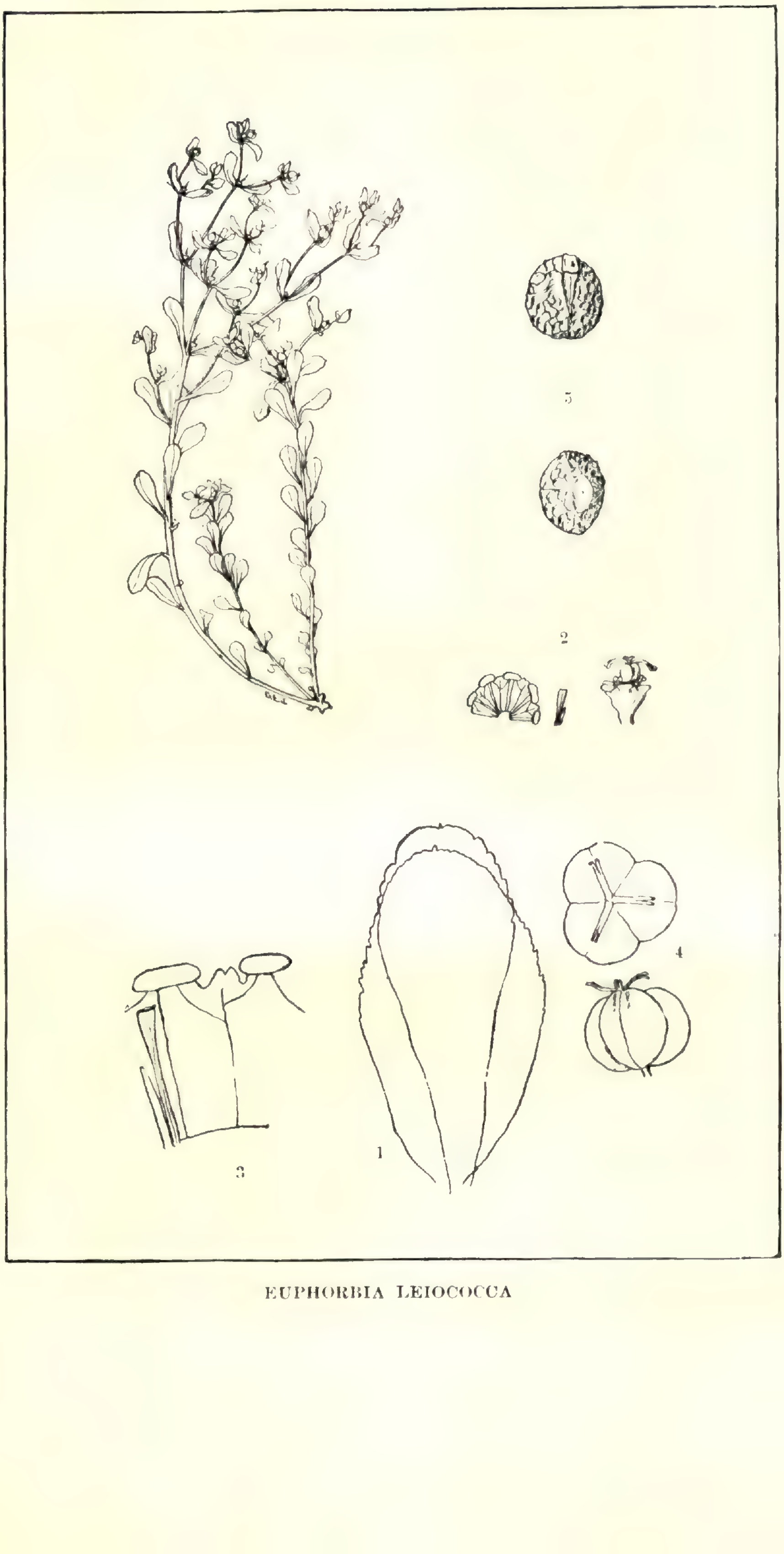

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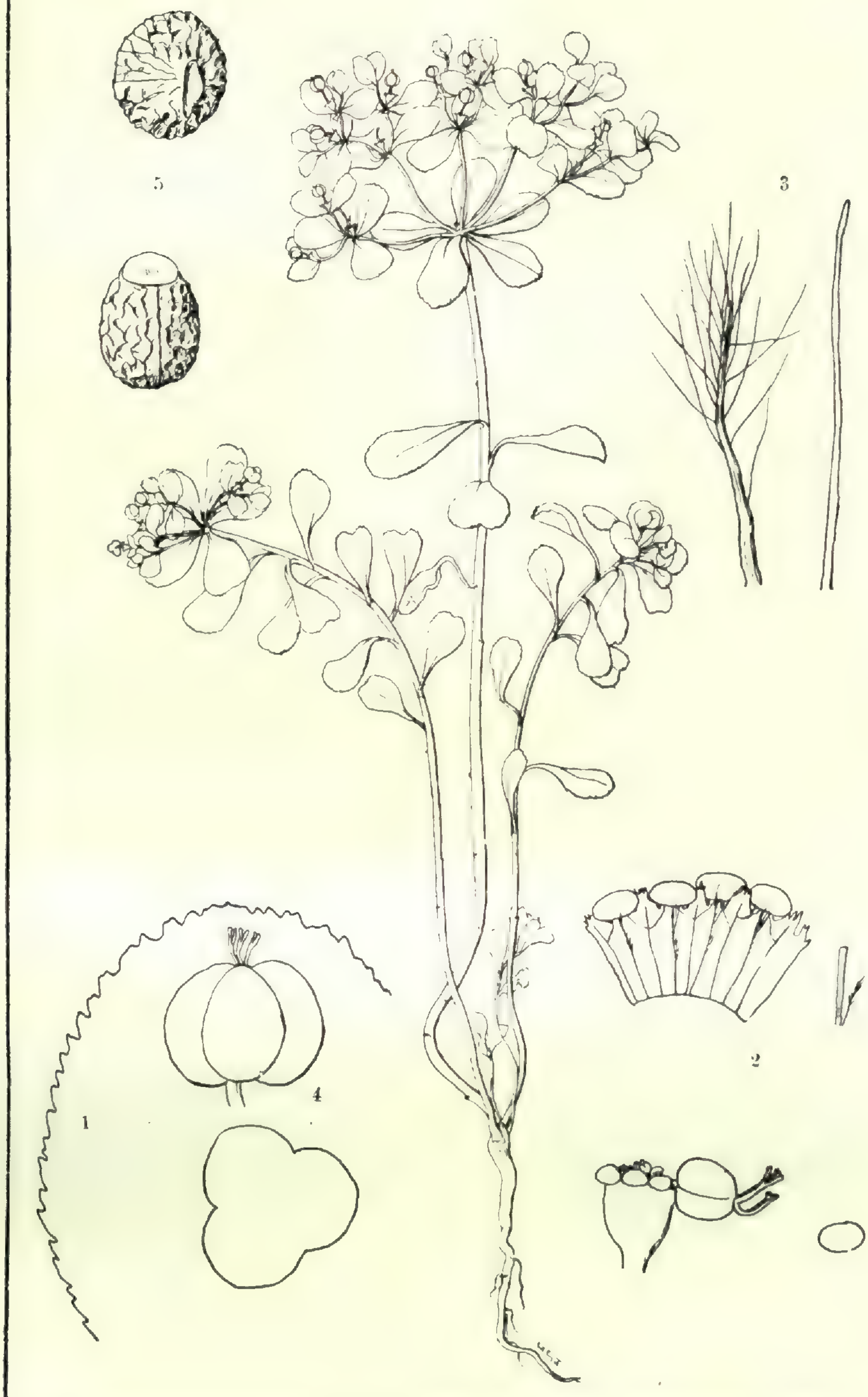

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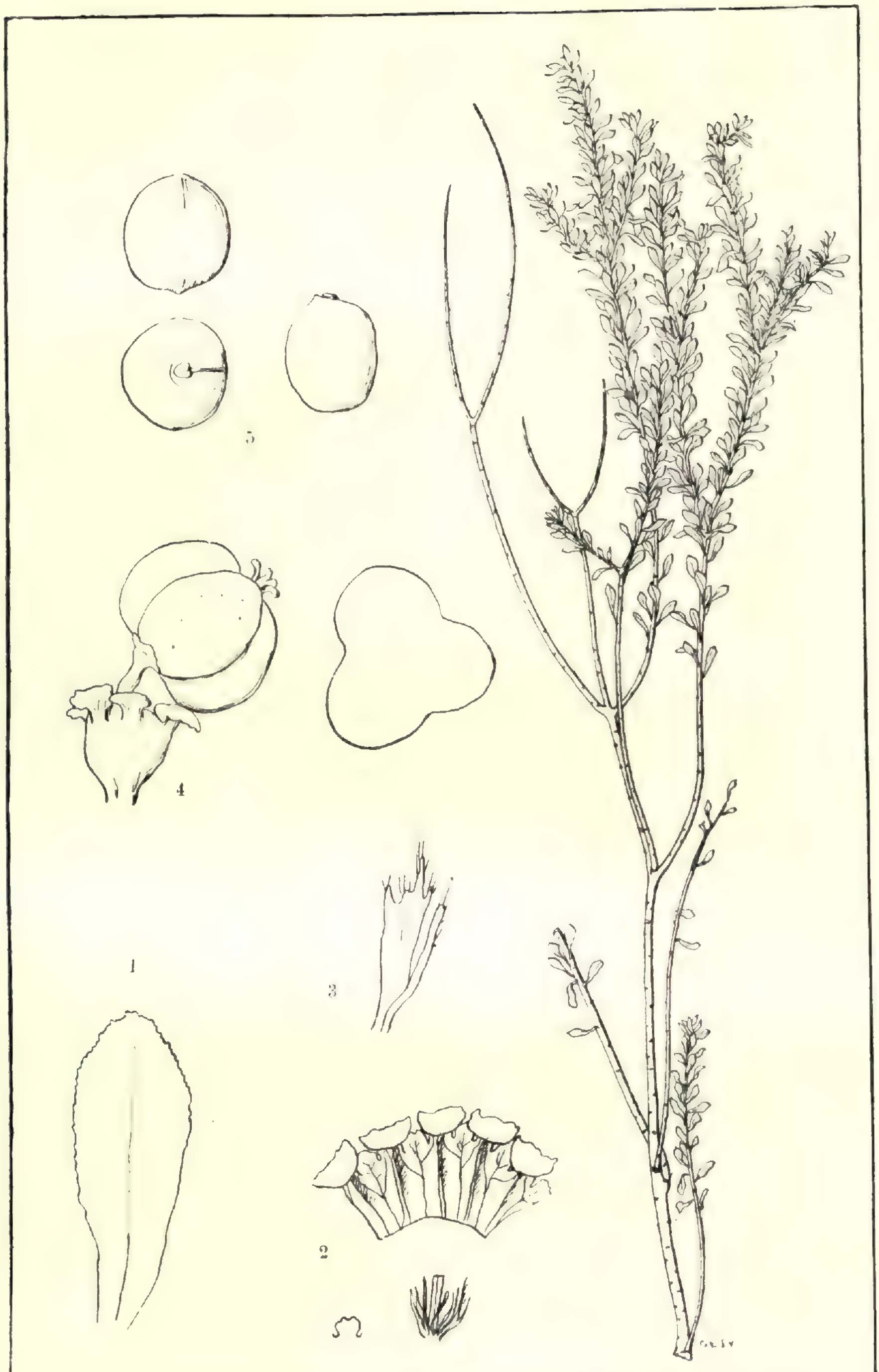

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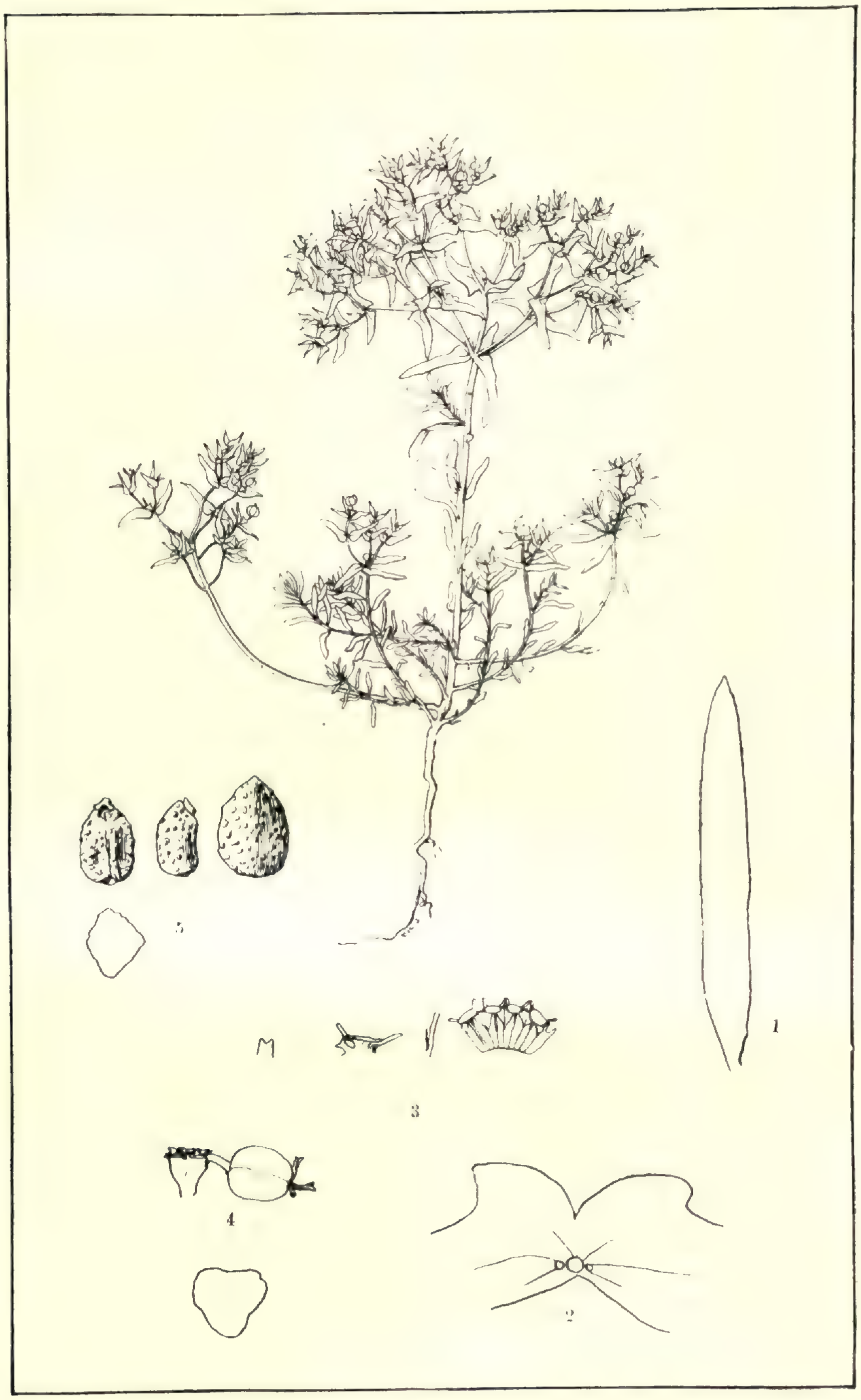

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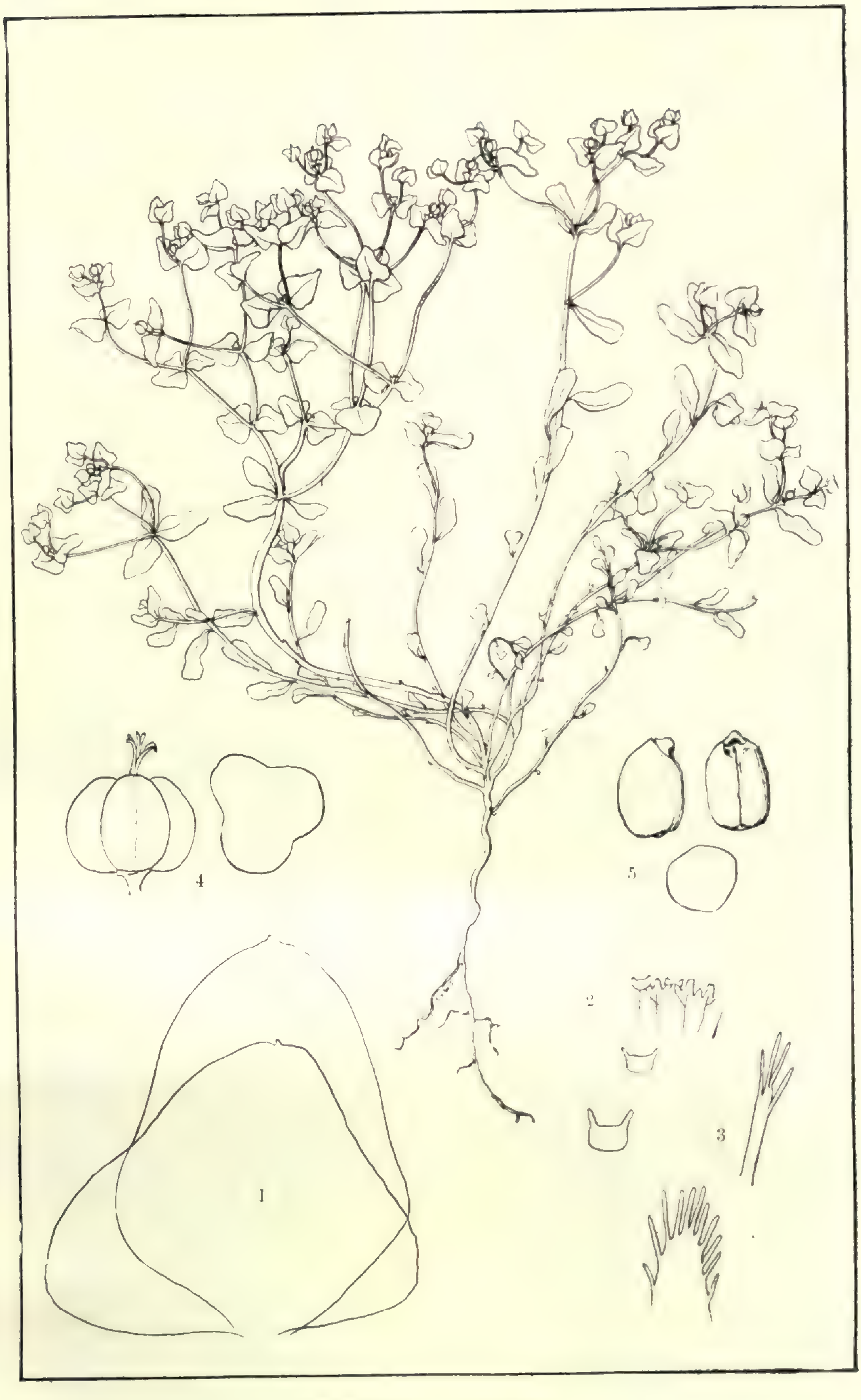

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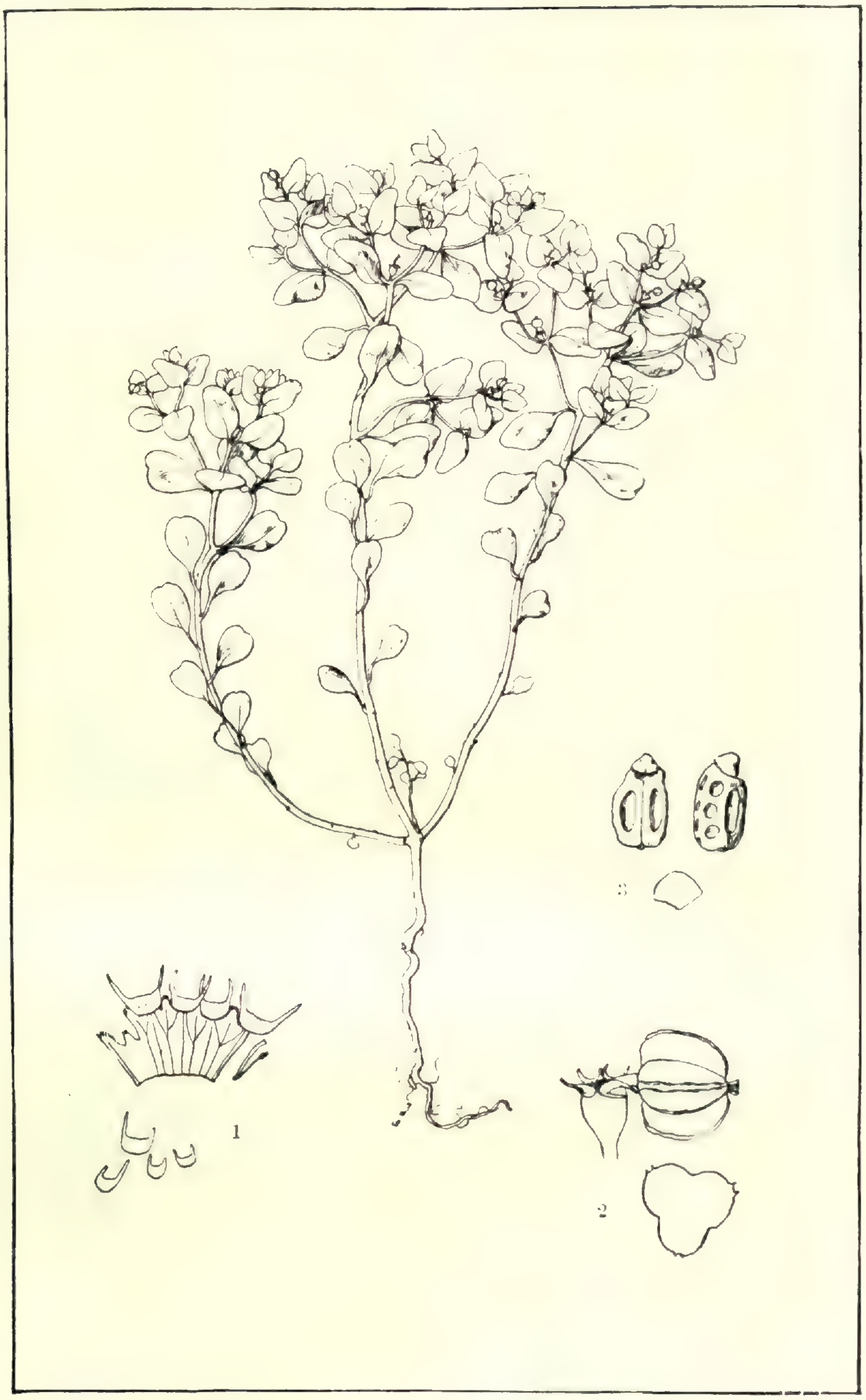

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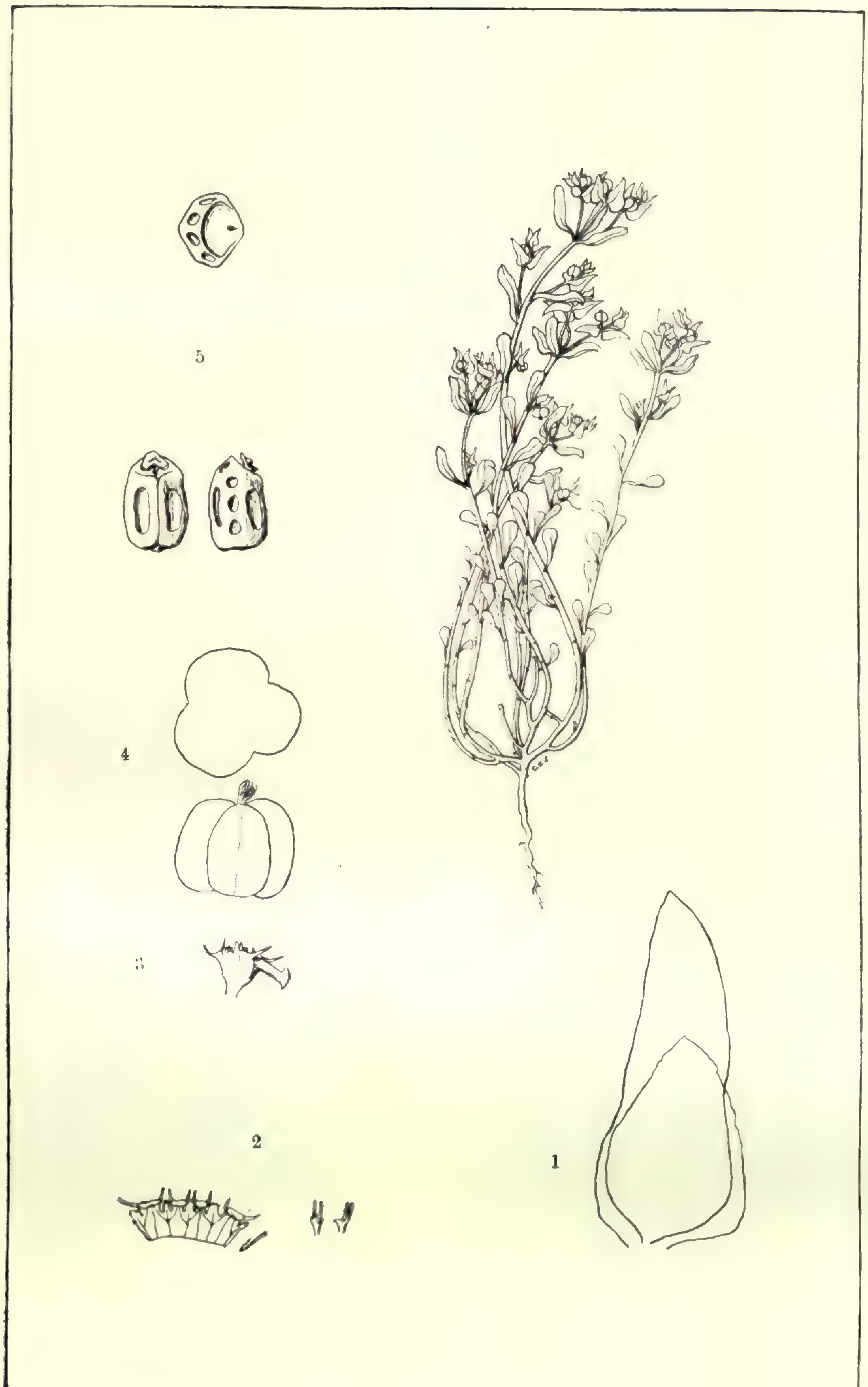

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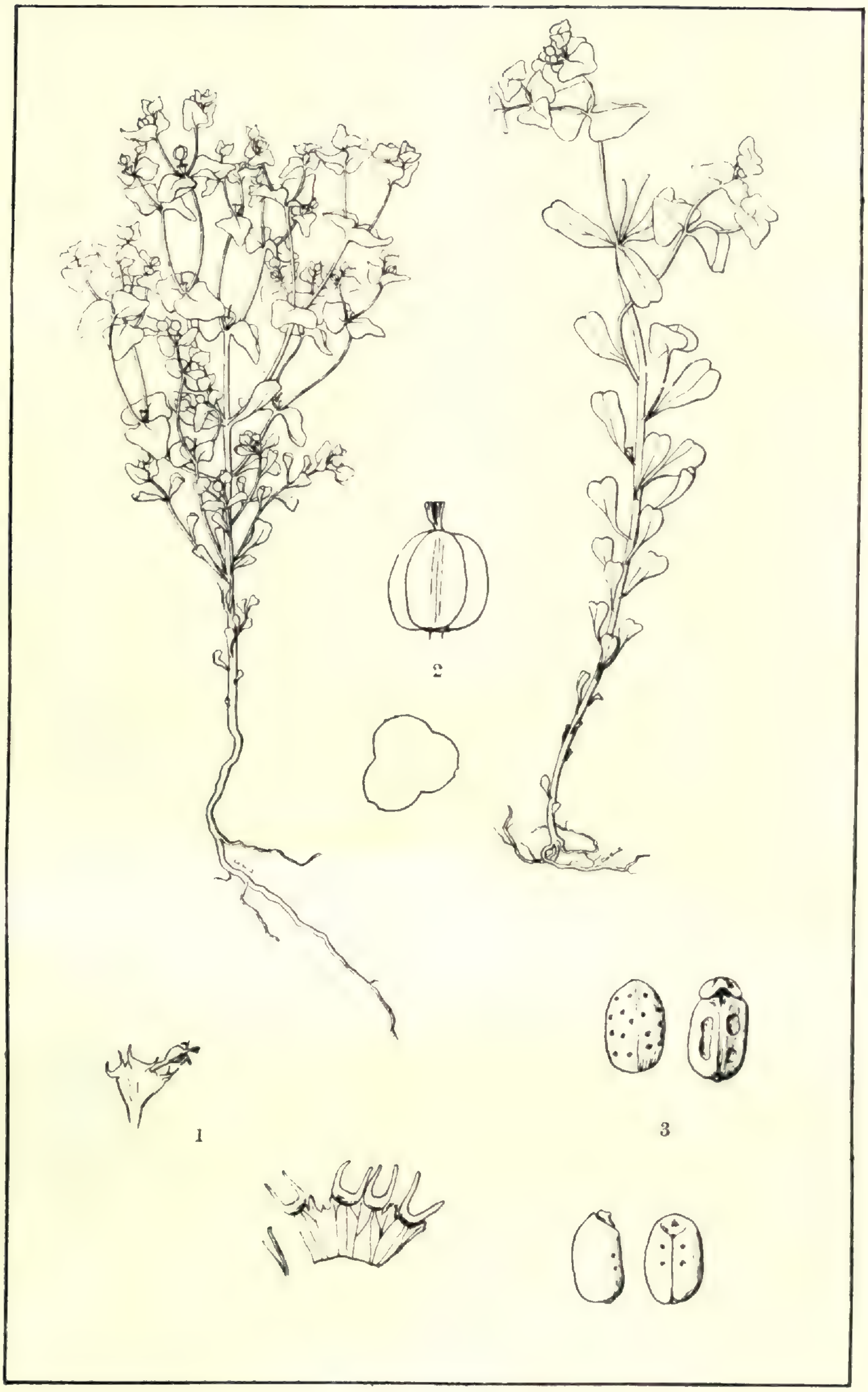

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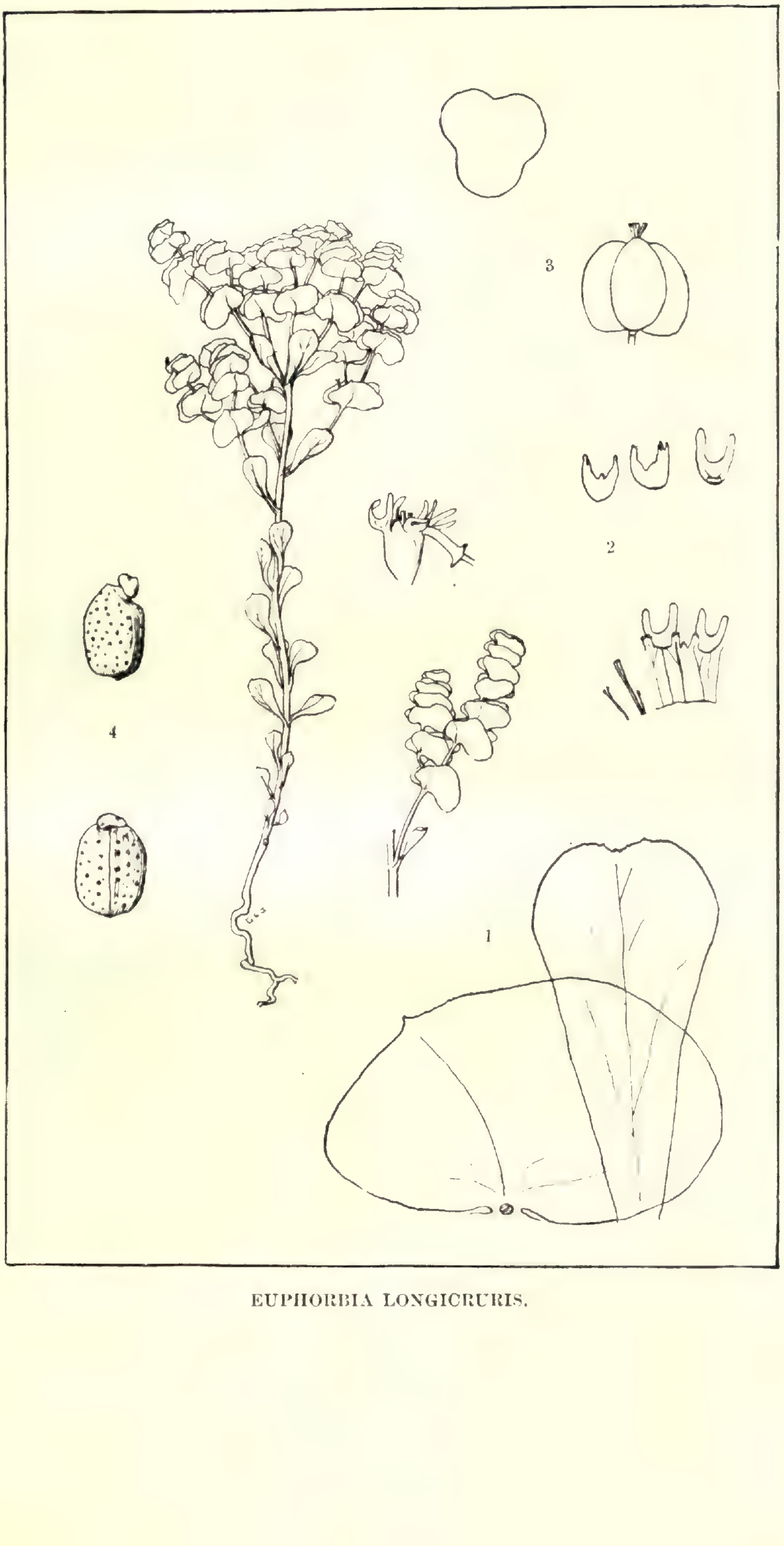

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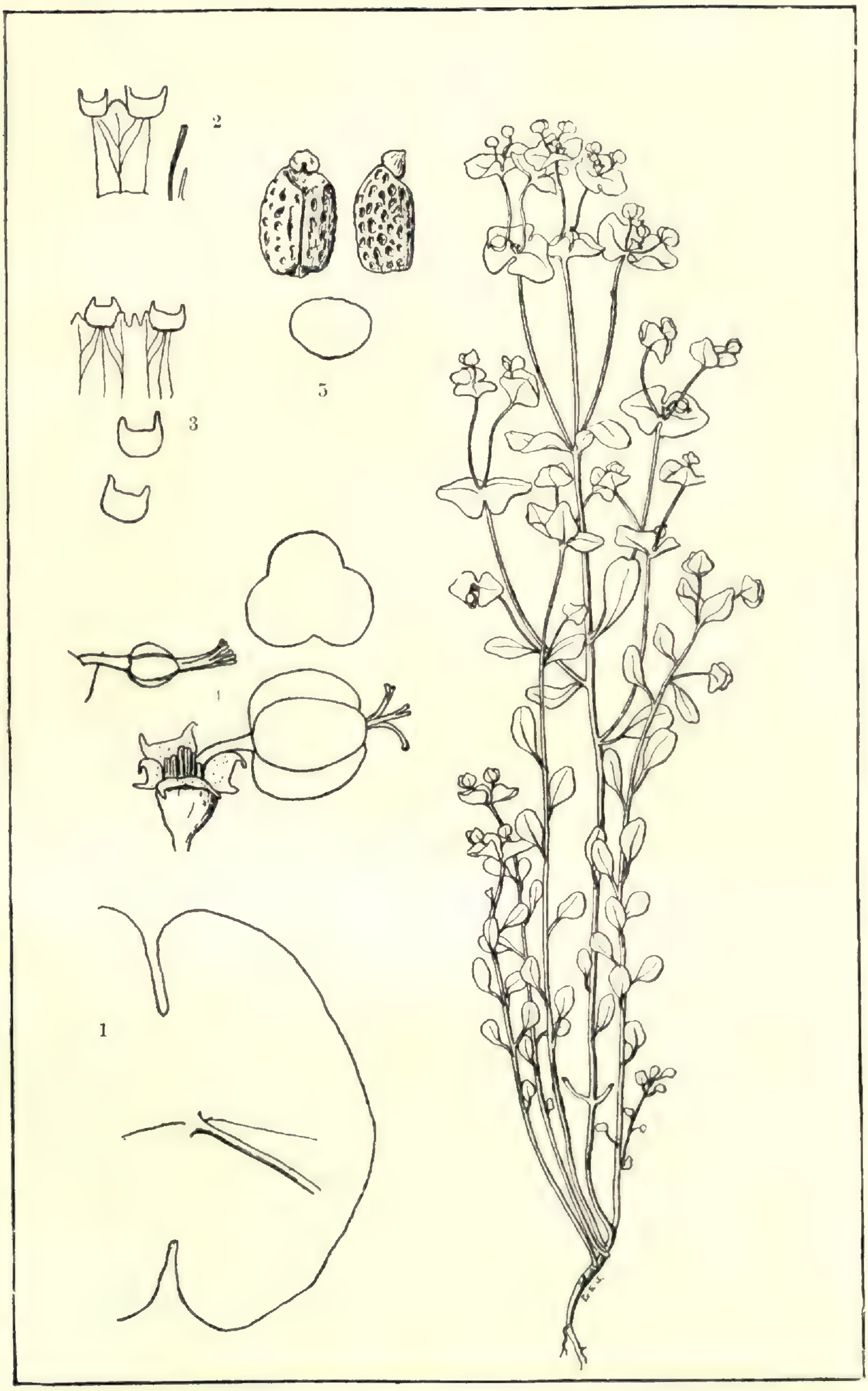

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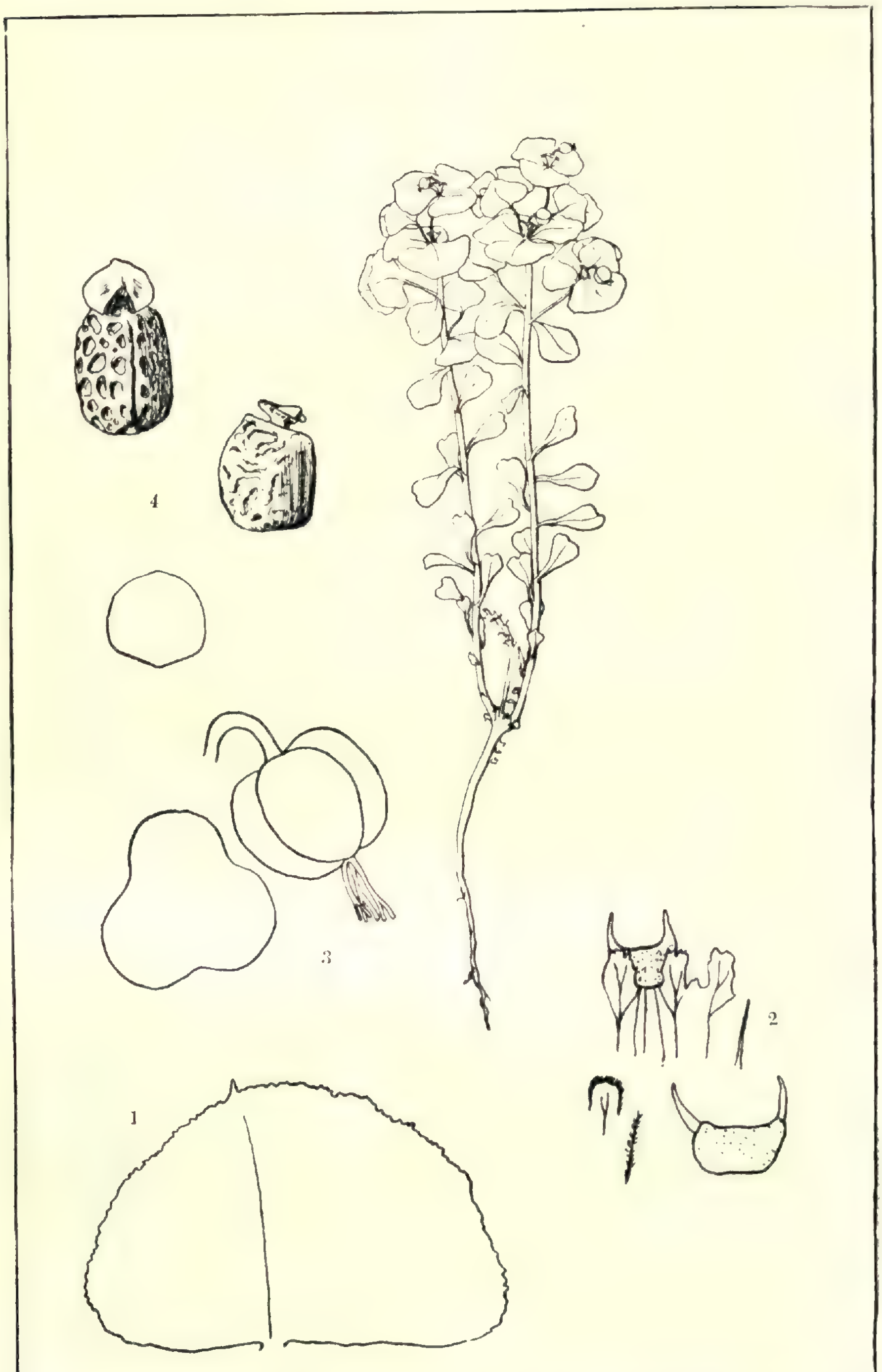

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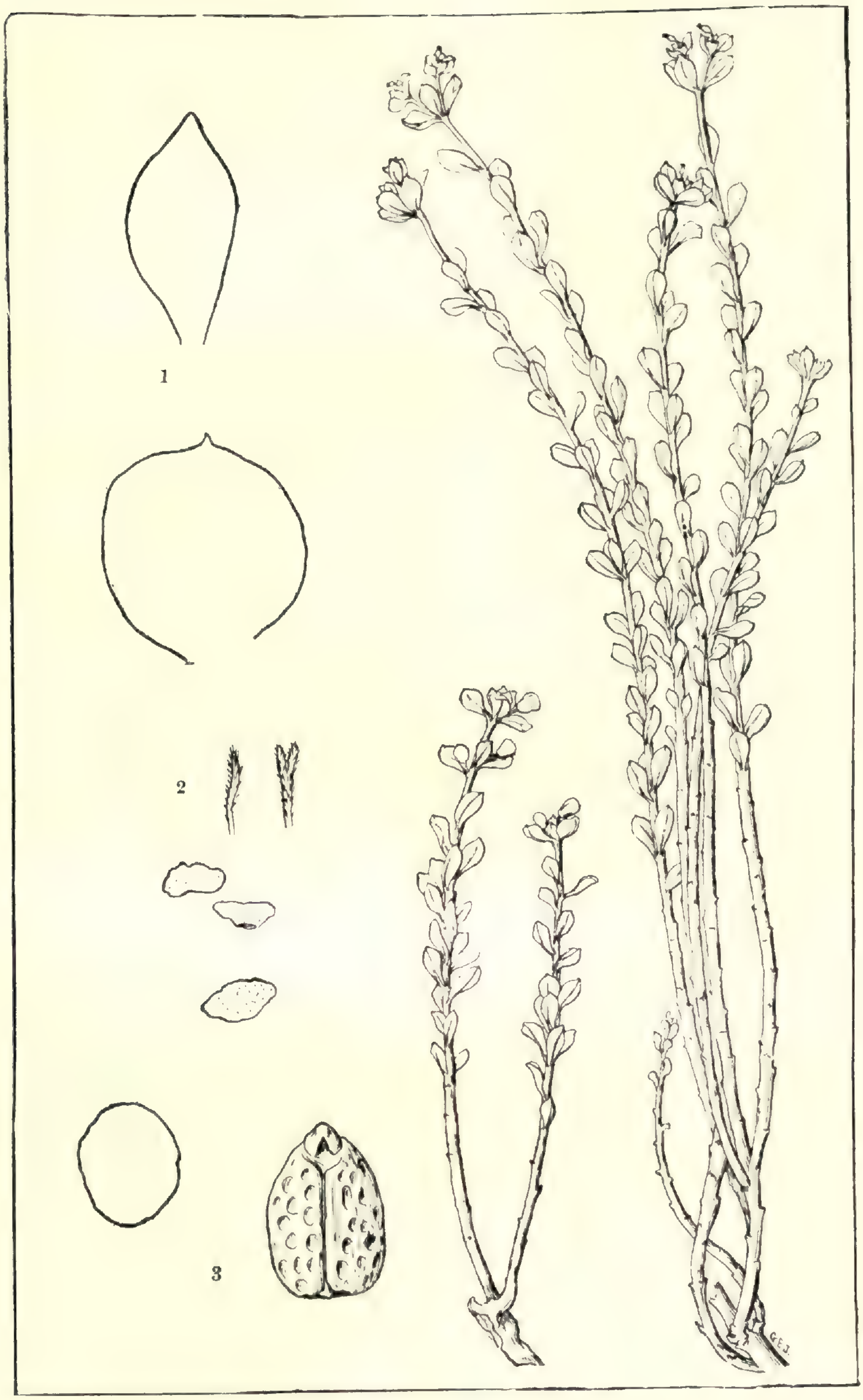

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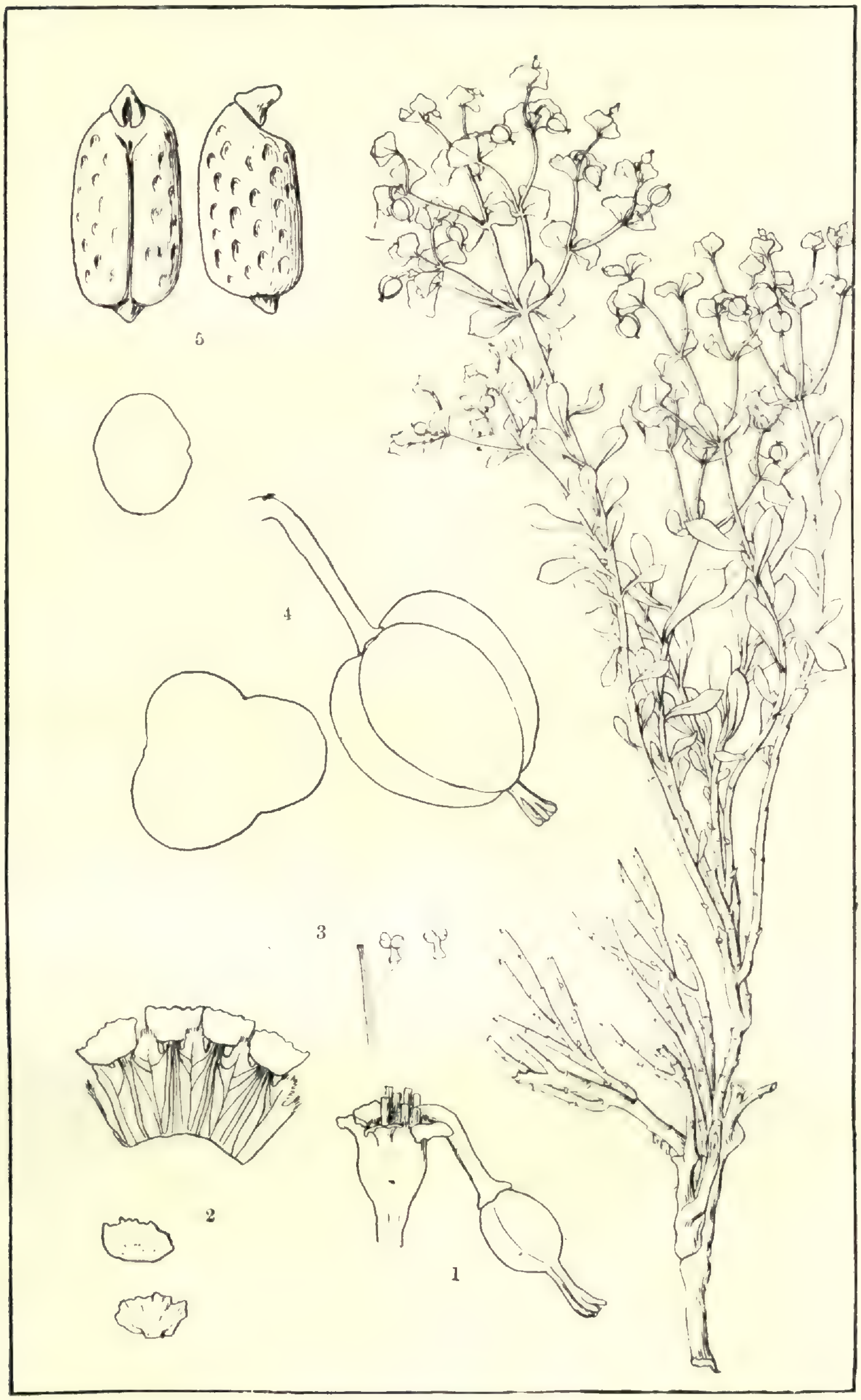

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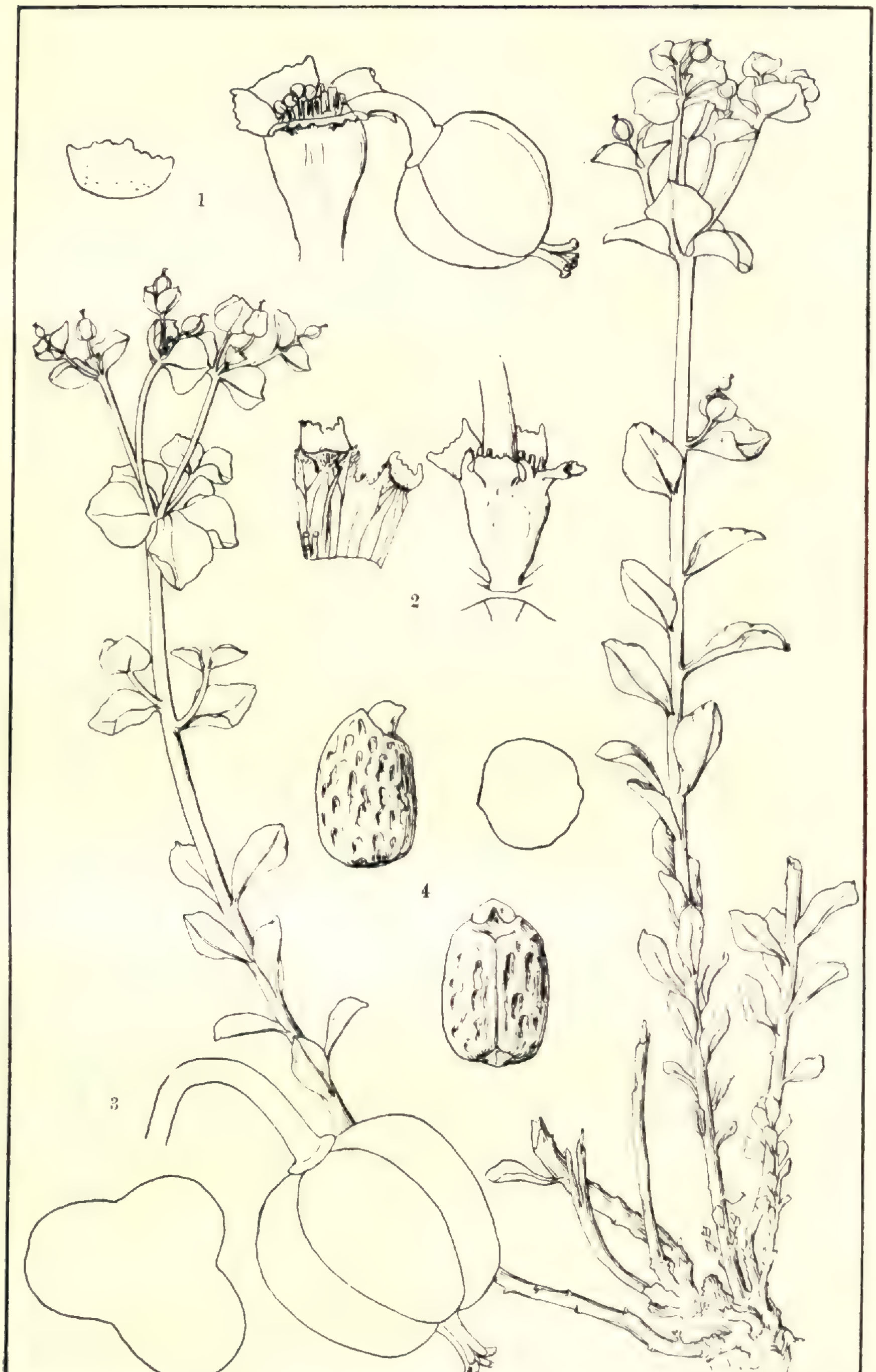

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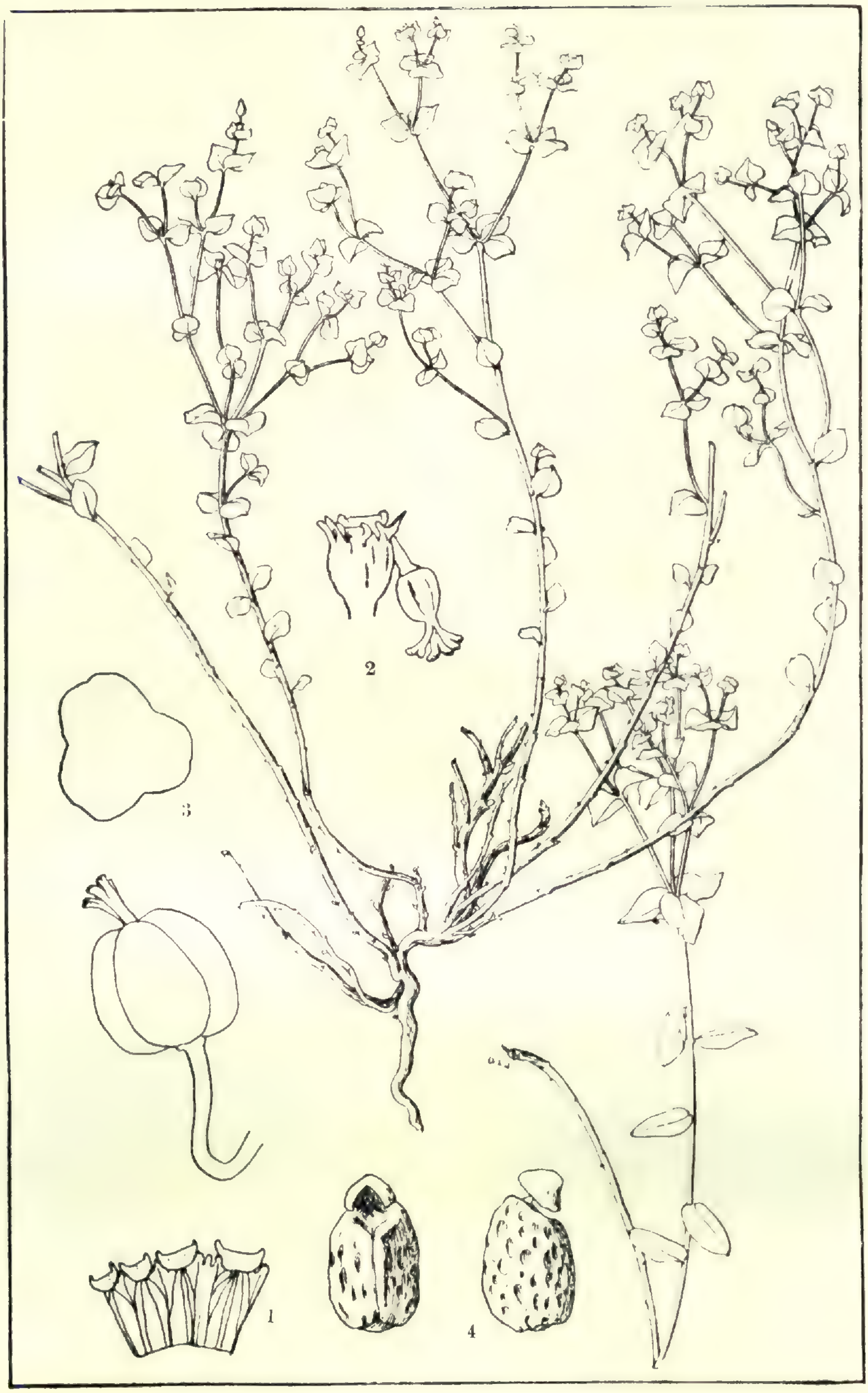

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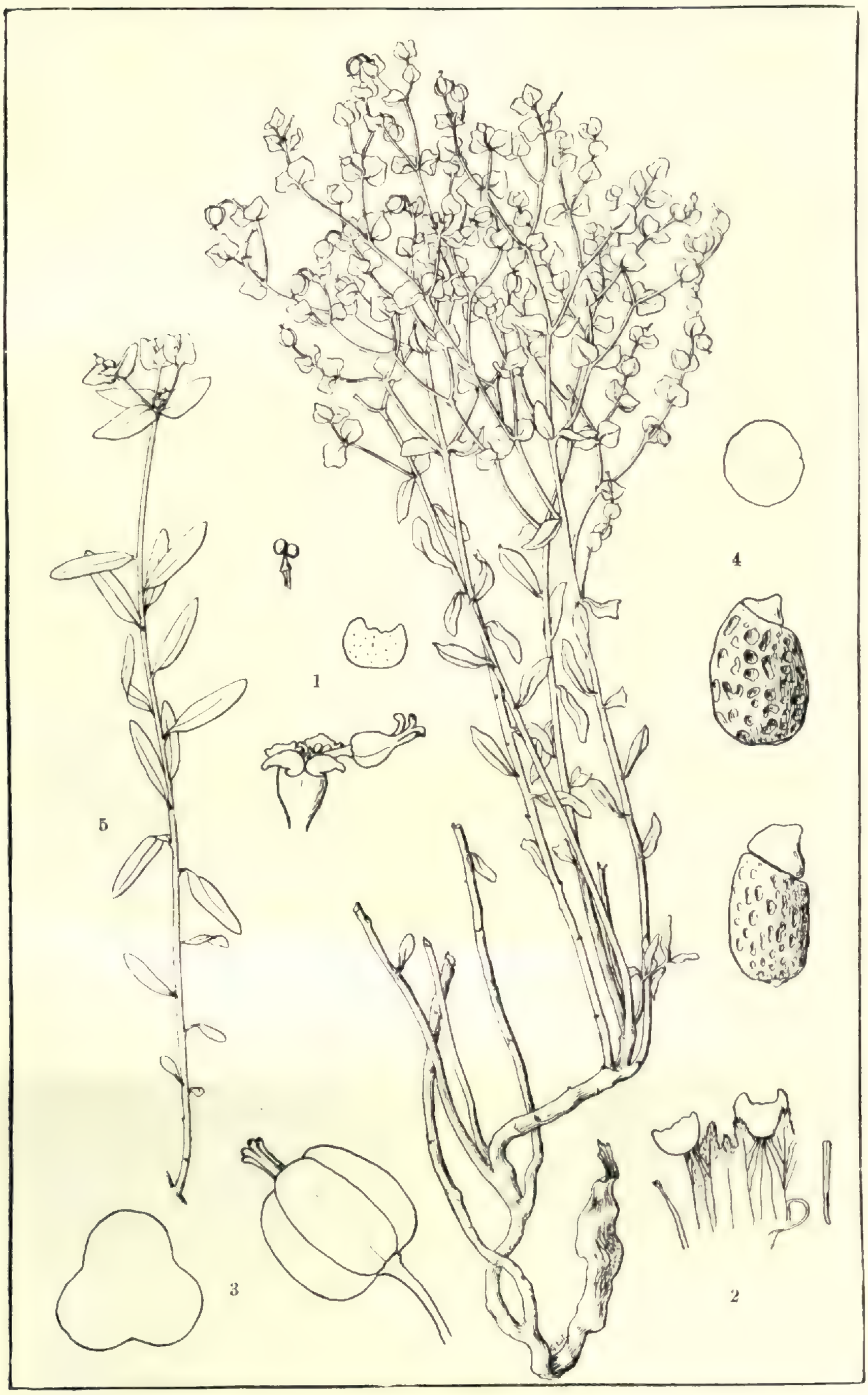

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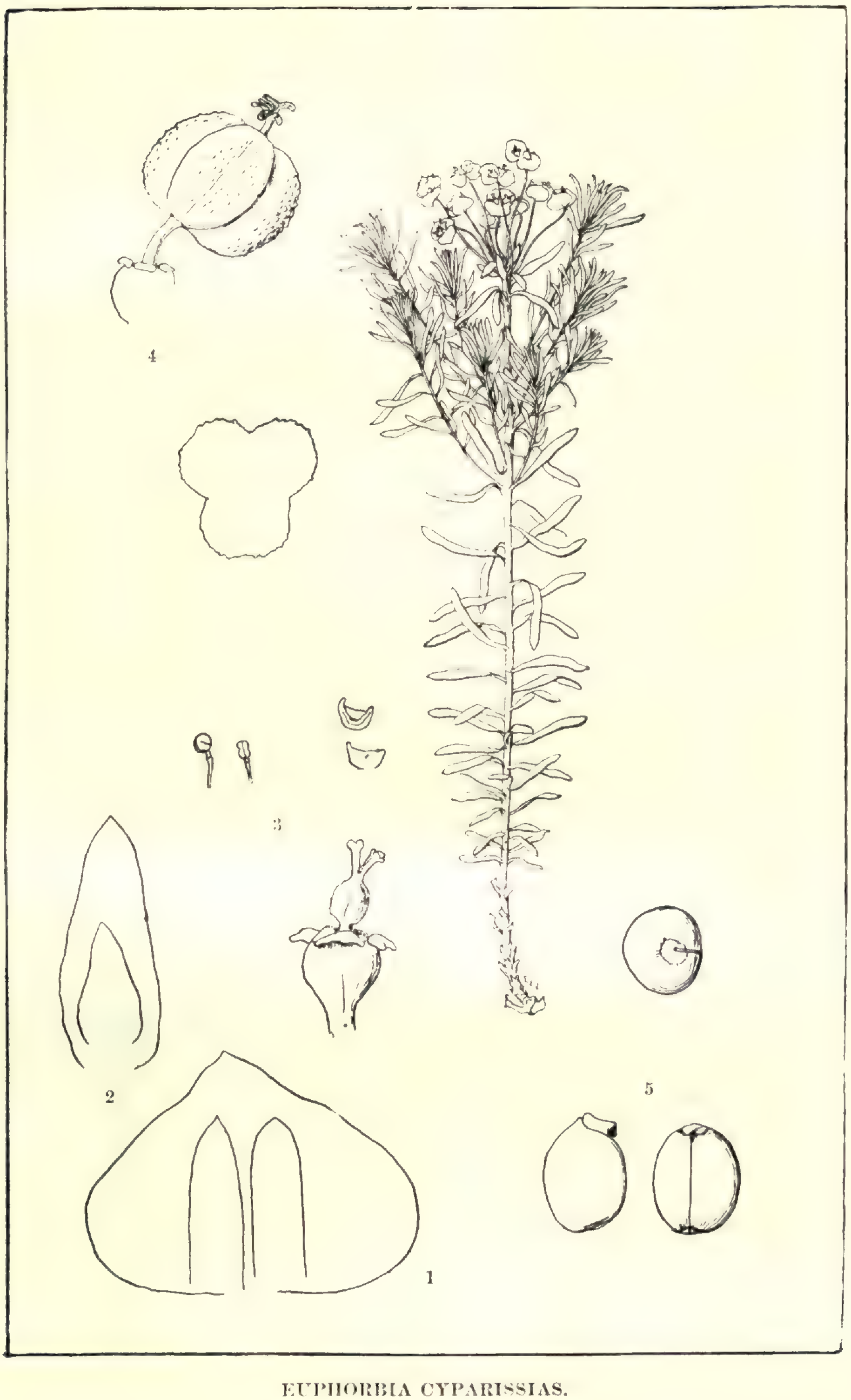


EUPHORBIA CYPARISSIAS.

EUPHORBIA ESULA.

EUPHORBIA LUCIDA.

REVISION OF THE SPECIES OF LOPHOTOCARPUS OF THE UNITED STATES: AND DESCRIPTION OF A NEW SPECIES OF SAGITTARIA.

BY JARED G. SMITH.

LOPHOTOCARPUS.

ANALYTICAL KEY TO SPECIES.

Petioles and scapes about equal, very slender; leaves hastate; dorsal wing of the mature achene inflated.

Fertile pedicels 3–5 cm. long, very slender, shorter than the 2 or 3 internodes; beak of the achenia very short. ***L. fluitans.***

Fertile pedicels equaling the internodes; verticils 5 or more. ***L. Californicus.***

Petioles thick and spongy, longer than the weak, ascending or at length decumbent scape; dorsal wing of the achene thin, flat, not inflated.

Leaves with sagittate or hastate blades, seldom bladeless. Plants growing in fresh water ponds and marshes.

Basal lobes of the leaves widely divergent: large plants, 2–6 dm. high. ***L. calycinus.***

Basal lobes not widely divergent: low plants, 1–1.5 dm. high. ***L. depauperatus.***

Leaves mostly bladeless phyllodia. Submerged seashore and tidal flat aquatics.

Phyllodia thick, spongy, nodose, 1–3 dm. long. ***L. spongiosus.***

Phyllodia flat, spatulate, not nodose, 3–7 cm. high. ***L. spatulatus.***

LOPHOTOCARPUS FLUITANS (Engelm.). *Sagittaria calycina fluitans* Engelm. in Torr. Bot. Mex. Bound. Surv. 212. 1859.

Submerged aquatic with very slender erect petioles 3–5 dm. high. Mature leaves sagittate, 6–8 cm. long, acute, the basal lobes shorter or longer than the middle one, 2.5–5 cm. long, 5–6 mm. wide, the middle lobe lanceolate, acute, 3.5–5 cm. long, 10–15 mm. wide; basal lobes sometimes very short, or obsolete (when the blade is linear-lanceolate), obtuse at the apex, and rounded or truncate at the

Separates issued September 27, 1899.

base, 4–5 cm. long, 7–9 mm. wide. Scape as long as the leaves; verticils two or three; fertile pedicels slender, 3–5 cm. long; fruiting head 8 mm. in diameter. Achenia obovate-cuneate, 2 mm. long, with a somewhat rounded or inflated dorsal wing or crest extending from the base of the short beak. New Mexico: Type No. 1899, C. Wright, 1852. No. 679, Wright, 1849, New Mexico, may also be referred here though the only specimen examined was fragmentary and imperfect. — Plate 53.

LOPHOTOCARPUS CALIFORNICUS n. sp.

Submerged aquatic, 3–4 dm. high, with weak, slender, ascending petioles 3–4 dm. long. Blades hastate or sagittate, the middle lobes 4–8 cm. long, lanceolate, acute, 5-nerved, the basal lobes widely divergent, $\frac{1}{4}$–$\frac{1}{2}$ as wide as the middle one, and shorter than or equaling it in length, linear-acuminate. Scape slender, nearly as long as the petioles, bearing 3–5 verticils of flowers, those of the two or three lowermost fertile. Bracts of the fertile whorls 6–7 mm. long, those of the upper staminate verticils 1 cm. long. Pedicels of the fertile florets 1–2 cm. long, equaling the staminate. Sepals orbicular, 6–9 mm. long. Verticils about the length of the fertile pedicels apart. Fruiting head 10–12 mm. in diameter. Immature achenia obcuneate, 1.5 mm. long, with a minute horizontal beak, broadly winged on each margin. — Plate 54.

Type No. 1136, S. B. & W. F. Parish, Coyote Creek, Los Angeles Co., California, October, 1891; also collected by J. A. Sanford, Stockton, Cal., July 16, 1893; both in Herb. Mo. Bot. Gard.

With the exception of an unidentifiable fragment in the Gray Herbarium, these collections are the only specimens of *Lophotocarpus* from California in either the Columbia, Harvard, St. Louis, or National Herbaria.

L. Californicus differs from *L. calycinus* in the very long, slender-petioled leaves, slender scape with 5 or more

verticils 1.5–2 cm. apart, and more broadly winged achenia, although mature specimens have not been seen. It is most closely related to *L. fluitans*, from which it differs in having widely divergent basal lobes, usually shorter than the middle one, more verticils less widely separated, larger fruiting head, shorter fertile pedicels, and more broadly winged and prominently beaked achenes.

LOPHOTOCARPUS CALYCINUS (ENGELM). *Sagittaria calycina* Engelm. Torr. Bot. Mex. Bound. Surv. 212. 1859.

Leaves floating or ascending, 1.5–4 dm. high. Blades entire, hastate, sagittate, or triangular crescent-shaped, dorsal lobes usually widely divergent, 8–16 cm. long, 5–25 cm. wide, rounded, obtuse or acute at the apex. Basal lobes often much longer than the middle one. Scape shorter than the petioles, simple, weak, at length decumbent. Verticils 2–6; fertile pedicels very thick, recurved in fruit, equaling or longer than the slender sterile ones. Achenes obcuneate, truncate, 2–2.5 mm. long, narrowly winged on the margins, with a short, horizontal, triangular beak. In fresh water bogs and marshes, South Dakota to Louisiana and New Mexico, eastward to Delaware. Type specimens in the Engelmann Herbarium. July–September.

Specimens examined from South Dakota (No. 7, Potter, 1892; No. 3, Griffiths, Bangor, Sept. 13, 1892; No. 5 and 14, T. A. Williams, Canning, Aug. 16, 1892); Michigan (J. Schneck, Grand Rapids, Aug. 24, 1881); Nebraska (No. 307, T. A. Williams, Greenwood, July 16, 1890); Kansas (Mark White, Cowley Co., 1898; No. 535, Hitchcock, Finney Co., Aug. 13, 1895); New Mexico (No. 74, Wooton, Mesilla, July 2, 1897); Missouri (Dr. George Engelmann, various localities around St. Louis; Bush, 404, Courtney, Oct. 11, 1896, and 675, Watson, 1894; Hilgard, St. Louis, 1870; Eggert, St. Louis, 1877); Illinois (E. Hall, Athens, and Sangamon River, Sept., 1861, and Athens, Sept., 1865; Hitchcock, Cahokia, Aug. 13, 1890); Louisiana (Josiah Hale, Alexandria, the type of *Sagittaria calycina maxima* Engelm., with paniculate inflorescence and broadly triangular leaf-blades 30 cm. wide); Delaware (A. Commons, Delaware City, Sept. 18, 1894). *Sagittaria calycina media* Engelm., collected in saline ponds along the Meramec river near St. Louis, Mo., July, 1856, only differs in having crescent-shaped leaves, rounded at the apex.

LOPHOTOCARPUS DEPAUPERATUS (Engelm.). *Sagittaria calycina depauperata* Engelm. in herb.

Low, 1–1. 5 dm. high. Petioles slender, ascending. Blades elliptical, hastate or sagittate, acute at the apex, 3-nerved, 2–4 cm. long, the lobes spreading. Scape one-half as long as the leaves. Fertile pedicels 1–3 cm. long. Fruiting head 7–8 mm. in diameter. Achenes obcuneate, truncate, 1.7 mm. long, 2 mm. wide, the slender horizontal beak one-third the width of the achene. Type collected by Dr. George Engelmann, Missouri, Sept., 1858. Margins of ponds, Wisconsin to the Indian Territory. June–September. — Plate 55.

Specimens examined from Wisconsin (T. J. Hale, Prairie du Chien, 1861); Illinois (H. M. Patterson, Oquawka); Missouri (Dr. Geo. Engelmann); Indian Territory (No. 331, E. Palmer, 1868; No. 268, M. A. Carleton, Cherokee Outlet, June 24, 1891).

LOPHOTOCARPUS SPONGIOSUS (Engelm.). *Sagittaria calycina spongiosa* Engelm. A. Gray, Manual, 5th edition. 493. 1867.

Submerged aquatic, with thick, spongy, nodose petioles and scapes. Petioles 1–2 dm. long. Blades spatulate and obtuse, or elliptical and truncate, or hastate, or sagittate, with the narrow, acute, falcately divergent lobes 2.5–10 mm. wide, sometimes 8 cm. long. Scape simple, not more than half as long as the petioles, spongy, weak, at first ascending, at length decumbent, bearing two verticils of one to three flowers each. Fertile pedicels much thickened, 1–2 or 3 cm. long, 3–5 or 6 mm. in diameter. Sepals broadly ovate, obtuse, scarious at the tip and margins, 10–12 mm. long. Fruiting head depressed-globose, 7–10 mm. in diameter. Achene 2–2.5 mm. long, obcuneate, with a narrow dorsal wing and a very short, ascending or horizontal beak. Margins of brackish ponds and tide-water marshes, New Brunswick to Virginia. Type collected by Edward Tatnall, Wilmington, Del., July, 1860, in Engelmann Herbarium. — Plate 56.

Specimens examined from New Brunswick (J. Fowler, Bass river, Kent Co., July 28, 1870); Maine (Swan, Kennebec, 1859); Massachusetts (W. Boott, Woburn Pond and Mystic River, 1863, and North Cambridge, Aug. 21, 1870); New Jersey (C. F. Austin, Hackensack River and New Durham, Aug., 1861; Wm. M. Van Sickle, Fairview, N. J., July 26, 1894); Virginia (F. V. Coville, Colonial Beach, July 6, 1890).

LOPHOTOCARPUS SPATULATUS n. sp.

Low aquatic, 3–7 cm. high, the phyllodia bladeless, or sometimes spatulately broadened at the tip, ascending, with the edges vertical through a twist in the base, 3–6 mm. wide, obtuse or rounded at the apex. Scape simple, usually shorter than the phyllodia, 3–4 cm. long, one or two-flowered, thickened and reflexed after flowering. Bracts minute, 3 mm. long, scarious, broadly ovate, obtuse. Stamens 6–9, the filaments flattened, incurved, broadest at the base, 1.5–2 mm. long, smooth, the anthers 1 mm. long, oblong. Sepals oblong-orbicular, thin, 3 mm. long, nerveless, thin-scarious on the margins, and papery in fruit. Petals ovate orbicular, obtuse, 6 mm. long. Achenia 1.5 mm., obliquely obovate, obtuse, narrowly winged on the back to about the level of the beak, and sometimes with a transverse lateral ridge near the top, with a slender, oblique or horizontal beak inserted below the apex. The phyllodia are frequently nodose towards the base. — Plate 57.

Collected by Alvah A. Eaton, Newburyport, Massachusetts, on sandy beaches along the Merrimac River, above salt water but within the influence of the tides. Mr. Eaton has had this plant under observation for five years, and says, concerning it: "The plant never gets larger, never has but one whorl of flowers, usually one or two, seldom three, on a scape. The fruit is buried in the mud in which the plant grows by the recurving pedicels and scape. Cultivation does not change the plant in the least, as I have had it in my water garden during the summer and in the greenhouse now."

Type specimens in Herb. Mo. Bot. Garden, and in the National Herbarium. This plant seems to be well distin-

guished from *Sagittaria calycina spongiosa* Engelm. with the type specimens of which it has been compared. The latter is from 10–25 cm. high, the strongly nodose phyllodia often bearing elliptical blades 2–2.5 cm. long. The achenia of *L. spongiosus* are cuneate obovate, 2 mm. long, and broadly winged on both margins, with the stouter beak nearly even with the tip of the achenium. The flowers are nearly twice the size of those of *L. spatulatus*.

Sagittaria.

Sagittaria Eatoni n. sp.

Monoecious, 1–2 dm. high. Phyllodia flat, broad at base, and gradually narrowed toward the tip. Leaf-blades when present linear-lanceolate, acute or acuminate, 2–3 cm. long, 2–4 mm. wide. Scape very slender, ascending, weak, 8–12 cm. high, bearing one, two, or rarely three verticils; bracts 2 mm. long, ovate, acute, connate. Fertile pedicels very slender, 5–8 mm. long, exceeded by the staminate ones. Flowers usually two pistillate and one staminate in the lowest verticil, the others all staminate. Sepals 4 mm. long, ovate-lanceolate, obtuse, 4–5 nerved, the nerves vanishing below the tip. Petals white, with a rose-colored spot at the base, broadly cuneiform-obovate, emarginate. Achenia not seen. Pistils very numerous in the female flower, 80–100, very minute. Stamens 12; filaments shorter than the anther, dilated at the base, pubescent. — Plate 58.

Collected by Alvah A. Eaton, Newburyport, Massachusetts, on sandy beaches along the Merrimac River, with *Eriocaulon septangulare*, between high and low tide, but above the influence of salt water. It is most closely related to *S. teres* S. Watson with which it has probably been confounded. It may be distinguished from that species by the flattened phyllodia which seem to be entirely without nodes, by the rose-colored bases of the petals, and by the fertile pedicels shorter than the staminate. I have seen

other specimens of this from Connecticut and the shores of Long Island, but from lack of full notes concerning habit of growth I have heretofore referred them to *S. teres*.

Mr. Eaton says: "This is peculiar on account of the extensive propagation by offshoots. It spreads by underground rootstocks or rhizomes, sometimes a dozen plants being joined, thus forming a complete carpet on the bottom in shallow places. The winter roots are like those of other Sagittarias. It likes positions where alternately covered and uncovered by the tides or where the sandy shore is ripple-swept. In the latter places it multiplies rapidly where its leaf-tips just emerge. Usually it is submerged and only blooms when it is so, at least for a part of the day by the tides. Its flowers open when the water is half way up. It does not seem to spread after it has been entirely left by the water, even though growing on the mud flats where it is very damp. It undoubtedly grows in all of our ponds with sandy shores."

EXPLANATION OF PLATES.

Plates 57 and 58 were drawn from the type material by Mr. A. H. Baldwin; the others, by Mr. J. B. S. Norton.

Plate 53, *L. fluitans*. — Plant, one-half size, and achenium, with cross-section of same, × 5.

Plate 54, *L. Californicus*. — Plant, one-half size, and immature achenium, × 5.

Plate 55, *L. depauperatus*. — Plant, natural size; achenium and cross-section of the same, × 5.

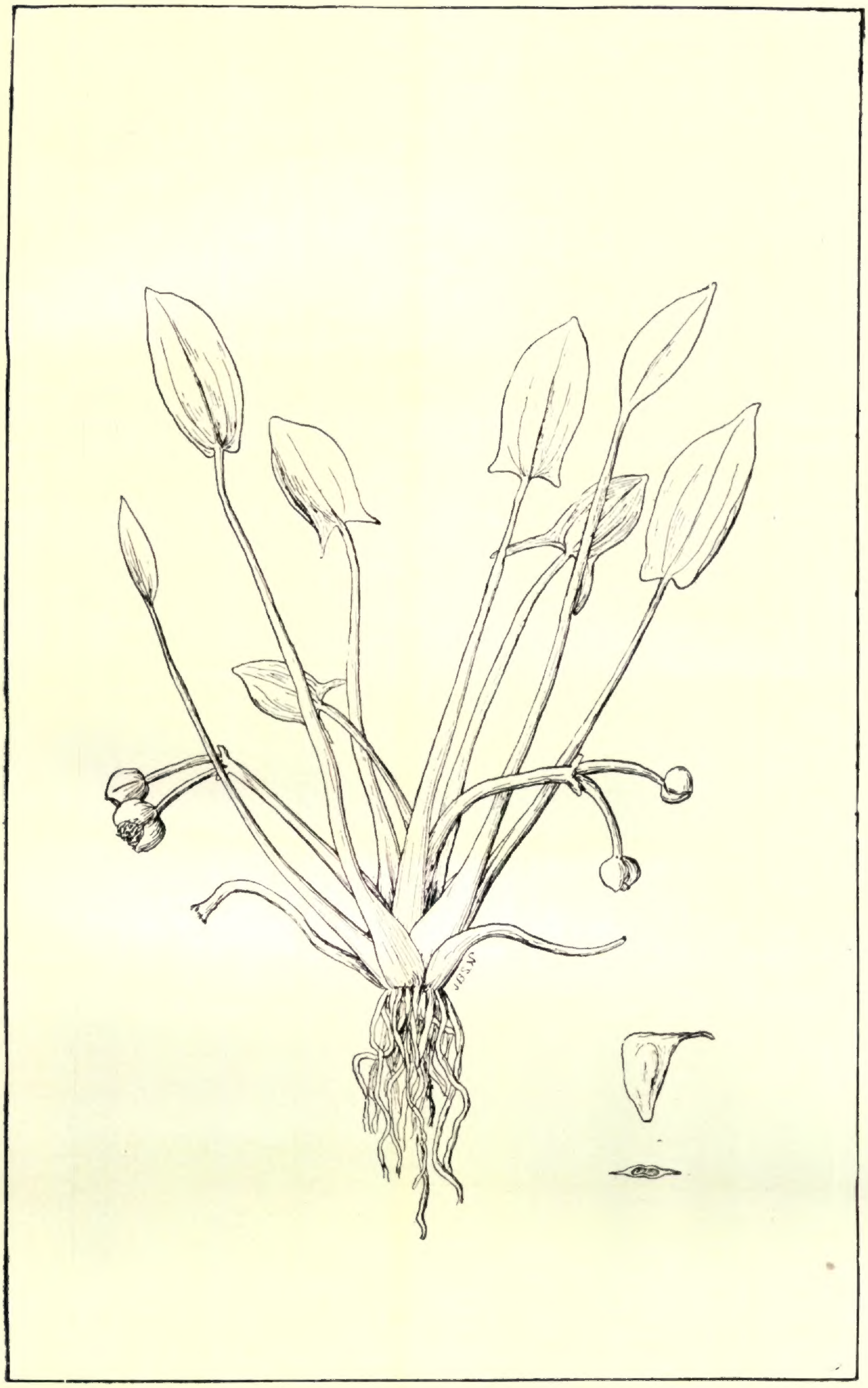
Plate 56, *L. spongiosus*.— Plant, one-half size; achenium and cross-section of the same, × 5.

Plate 57, *L. spatulatus*.— 1, Plant, natural size; 2, sepal, × 5; 3, petal; 4, stamen, × 20; 5, achenium with cross-section, × 10.

Plate 58, *Sagittaria Eatoni*. — 1, Plant, one-half size; 2, flowering branch, one-half size; 3, sepal, × 5; 4, petal; 5, stamen; 6, pistil.

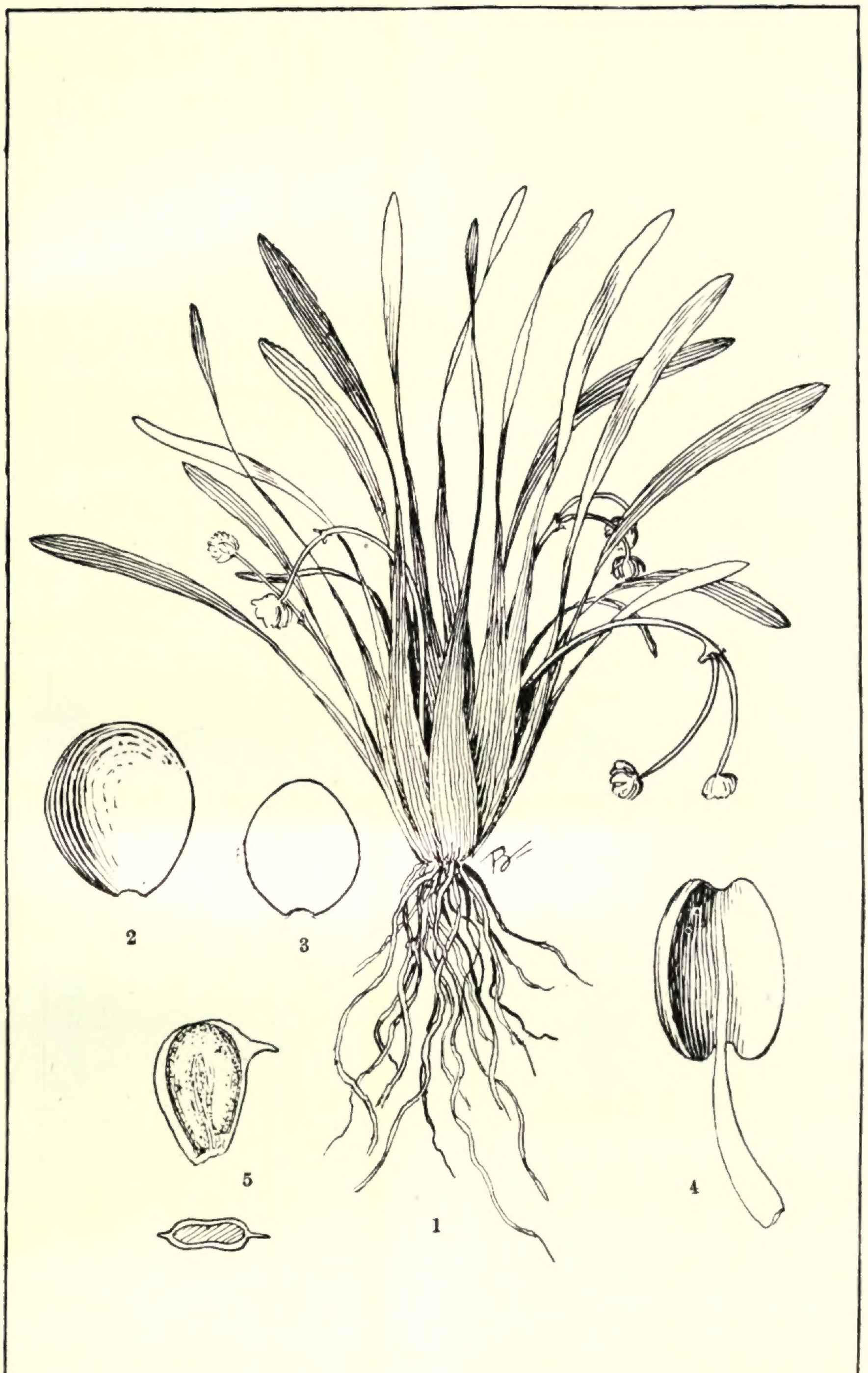
LOPHOTOCARPUS FLUITANS.

LOPHOTOCARPUS CALIFORNICUS.



LOPHOTOCARPUS DEPAUPERATUS.

LOPHOTOCARPUS SPONGIOSA.



LOPHOTOCARPUS SPATULATUS.

SAGITTARIA EATONI.